

# ANNALS of SURGERY

A Monthly Review of Surgical Science and Practice

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# ANNALS *of* SURGERY

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## OPERATIVE TREATMENT OF FRACTURE OF THE SPINE UNCOMPLICATED BY CORD INJURY

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DURING the past few years, the profession has learned that fracture of the spine is a much more frequent injury than was at first supposed. Many of the cases do not give the cardinal symptoms, and it is only by the routine use of the X-ray in injuries of the back that we are learning to recognize them. Many of the cases of so-called "back strain," "railway spine," etc., in which the symptoms were considered to be largely functional, we now are agreed are caused by definite injury to the spinal column itself. A surprisingly large number of these are quite free from cord or nerve-root symptoms, and, in many, such symptoms are present to a slight degree, and disappear in the early days after the injury. A study of the old cases of fracture demonstrates that a large majority suffer a prolonged and permanent disability and that this disability is due to an interference with the function of the spinal column, and not with the cord, the meninges, or the nerve-roots. Since such a large number show this long and permanent disability, even with careful supportive treatment, and also since this disability is due, in part at least, to the interference with the weight-bearing function of the spinal column, it becomes a vital question whether these cases should not have the benefit of operative treatment, with the object of firmly fixing the spine at the site of fracture. The fixation of the spine by an internal splint, inserting the single graft in the spinous process, by the method of Albee, or by the double graft, on either side of the spinous processes, or by ankylosis, according to the method of Hibbs, are all well enough established to insure the result of a stiffened area. This has already been done by the writers in a number of cases, and the object of the study which has been made in the series here reported is to determine by a comparison of the results, in non-operative and operative cases, whether it is advisable to recommend the operative procedure in cases of fractured

spine, and if so, in which cases, and when. The available old cases of undoubted fracture have been looked up and their conditions studied. Both fresh and old cases have also been included in the series, and the comparative results of the study of the two classes was pursued with the object of determining the comparative data. The cases have been studied with reference to the types of injury to the spine, the period of partial or permanent disability, and the symptoms which accompany it, as well as the effect of the mechanical treatment by fixation and support.

The condition after operation in the old disabled cases has been included in the series, and from this study the attempt has been made to determine which type of injury is most liable to result in the very long or permanent disability, and in which cases, if in any, it is best to operate.

The prolonged disability in cases of fracture of the spine has been mentioned by many writers, but the treatment advocated has been conservative and mechanical in a very great majority.

In general, operation has been discouraged, although the discouraging outlook has been admitted, even with the use of apparatus.

E. P. Palmer suggested an insert of a graft after laminectomy over the area in which the laminae were removed, but this was after the first operation had been done, and was in a case which had presented nerve symptoms sufficiently pronounced to warrant operation for cord pressure.

P. W. Roberts, in a report of four cases, suggests that bone grafting may be used when support has been worn for a reasonable length of time without improvement and when all other treatment has failed, but the operation was not done on any of the cases reported.

Albee, in his "Bone Graft Surgery," states that bone graft is indicated in cases of fracture of the spine with persistent non-union and increasing deformity, but he reports no operated cases.

Sever, in his report of eleven cases, states that the repair is usually good in the lumbar region, and that the supporting function is generally good, even in spite of the kyphos, which may tend to increase, but adds that permanent disability, as far as laborious work goes, generally follows such an injury. It would seem, however, that such cases should be grouped among the partially disabled class, and not among the recoveries.

Hartwell, in his history of eleven cases of fracture without paraplegia, calls attention to the frequent failure of mechanical measures, and advocates operation by graft when pain is not relieved by plaster jackets or if there is an increasing knuckle.

The bad prognosis in most cases, as well as the severity of the early disability, led us to operate early on a few of the fresh cases. The permanent disability in some of the old cases, which had had, or were having at the time, mechanical treatment, led us to operate on some of them. The results on both of these were so encouraging that the cases have been gathered together for comparative study.

The cases in this series include only those which had no, or only

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temporary, nerve symptoms, and with which the repair of the spinal column alone was in question. No case has been considered in which the diagnosis could not be unquestionably confirmed by röntgenological findings, and many of the recent cases, with whom we were able to communicate, have had stereoscopic radiographs, in order to rule out every possible chance of error.

Twenty-seven cases of fracture have been studied, of these ten were of the dorsal, and seventeen of the lumbar spine, and of this total number, nine were operated upon. The character of the trauma varied greatly. Sixteen cases were injured by falling variable distances, from eight to sixty feet, but striking in the most part in a position to cause forcible forward flexion of the spine. Two were suddenly forced into a flexed position, three caused by falling embankments, one dragged by a freight car, one forced through a mangle, one caught between freight cars, one struck by a train, and in one injury not known. Disability, because of pain, was immediate in all, except the one in which the man was caught between freight cars, who felt some pain at the time, but after being extracted continued with his work for about twenty minutes, when he pulled a switch, felt sudden pain in back, and fell unconscious. Another recovered sufficiently after two weeks of recumbency and two weeks of rest to work for three months, when pain returned, but was able to work for two months, when pain became so severe as to cause complete disability. Severe local pain and tenderness were constant factors. Pain referred down one or both thighs was frequent, and occurred in a large proportion of the lumbar fractures, while in those of the dorsal the pain seemed more commonly to be local. Tenderness over the point of fracture was found in every case, and the symptoms were all largely relieved by recumbency.

The presence of deformity is practically constant; kyphos or dis-alignment were found in all, kyphosis being the predominating deformity. The motions of the spine were limited and attended by muscle spasm and pain, as would be expected, except in a few, in which there was abnormal mobility at the site of fracture. Hip motions were, as a rule, free, with the exception of those which caused motion of the pelvis, and thereby of the spine, and caused pain either locally or referred down the thighs. This was true to a certain extent in both dorsal and lumbar fractures, but was more frequent and more severe in those in which the lumbar spine was involved.

Twenty-two of the cases were treated by recumbency and support. The time of recumbency of fifteen was less than one month, and the additional treatment by support and fixation was from three months to four years or more. A second, two years and ten months after the injury, could do light work only, and the motions of the back were very much limited. A third, in which ten years have elapsed since injury, has been able to return to his former occupation because it was not laborious. He had sufficient pain in his back to cause him, as he says, "to feel it," and heavy lifting is impossible. A fourth, two years and ten months since injury, is able to do light work, but only a portion of the time. Any occupation which necessi-



tates bending his back causes disability and pain. He is not a skilled workman, and has been unable to secure suitable work. A fifth, in which the fracture was a complete crush of the body, with some dis-alignment, was disabled for six months. One year following the injury he was working as a laborer. His back motions were limited, but the functional result seemed very good. It is now eight years since the injury, and he has had no return of symptoms. A sixth, in which there was evidently an impaction of the transverse process of the first lumbar with the twelfth dorsal, has returned to his former occupation, and is free from symptoms. It is now nine years since the injury, but unfortunately the exact length of his disability could not be determined.

Of the cases of the dorsal fracture, one, a crushed fracture of the bodies and of the laminae of the ninth or tenth dorsal, with marked dis-alignment of the fragments, is now wearing a leather jacket during the day, two years since the injury. His occupation has been changed to one necessitating less physical strain and less income. He is never free from pain at the site of the old fracture, and the motions of his back are very much limited. A second, a crush of the twelfth dorsal with marked dis-alignment, was still totally disabled by pain one year after injury, but now has unfortunately disappeared, and the present condition is not known. A third, a lateral crush with dis-alignment, two and a half years after injury has a fair amount of motion, but complains of pain and weakness of the back. Change of occupation was necessary. A fourth now wears a leather jacket a portion of the time, six years after injury. He returned to his former occupation after four years of practically complete disability. A fifth, five years after injury, has considerable pain in the back. All back motions are very much limited by pain and muscle spasm. She has been able to do light work for the past two years, but for the first three years was totally disabled. A sixth, a crush of the body of the twelfth dorsal with fracture of the lamina, is wearing support at the present time. It is six months since the time of injury, and he is unable to do any work because of back pain. This case was complicated by the fracture of the surgical neck of the humerus.

Nine cases have been treated by a bone graft, inlaid in the split spinous processes, extending two vertebrae above and two below the site of fracture. These cases were kept recumbent in a plaster shell or jacket for two months after operation. Of these five had had mechanical treatment and were still disabled. The remaining four were operated on in the early stages (within eight weeks) and can be grouped as fresh cases or cases untreated by mechanical measures. These cases, however, were all treated by recumbency or by support during the interval preceding the operation.

It is easily seen that the cases which have had the usual mechanical treatment have shown, in general, a prolonged disability. A comparison of the cases treated by mechanical means only, and those by operation shows the following.

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Of this series of twenty-seven cases twenty-two received mechanical treatment by recumbency and support. Of this twenty-two, four recovered, eighteen showed persistent partial disability. By recovery is indicated freedom from pain, ability to return to same or similar occupation. One of these four (Case XVII) is placed in this group, although the patient has taken a lighter form of occupation and still wears support a part of the time, but is free from pain, and is satisfied with his condition. The remaining eighteen show partial recovery, indicated by continuance of pain and inability to return to the usual or to like occupation. The time over which this period extended varied from four months to four years or more.

Of these, Case II was disabled at the end of four months, but disappeared. One (Case XXVII), still totally disabled at the end of five months, was operated upon, and one (Case XIII), still disabled at the end of six months, has since disappeared. With the remainder, the disability was known to have extended over a period of at least one year.

Of the nine cases operated upon, three were old fractures, which had shown only partial recovery. Since operation these three are free from the pain and disability which had existed before, and the patients are able to take up their occupations. These three (Cases XXIII, XXIV, XXVII) are included in the list of partial recoveries by the mechanical treatment, and were operated upon only after failure to obtain relief by this means.

Six of the operated cases were recent fractures. The earliest (Case XXV) was operated seventeen days after injury. The patient removed the support on his own responsibility in eight weeks, and returned to work three months after operation, and called himself well. One (Case XXII) is put in this group operated upon three months after injury, at which time the patient was completely disabled, and had an increasing knuckle. Six months after operation he was working full time as a lineman. One other (Case XXVII) returned to work at the end of five months and was comfortable. Two are more recent, eleven months or under since operation, are free from pain, and are active but not working. The last (Case XIX) is too recent for statistical value.

Thus for comparison of twenty-two cases treated by mechanical support, four show recovery, with eighteen partially disabled. Of nine cases operated upon, three were of old fractures, six were fresh, all of which show recovery, the time varying from three to six months. One has not yet had the test of work, but is active and free from pain.

It is fair to state that several of the twenty-two cases did not receive thorough or prolonged mechanical treatment, but, on the other hand, many of the cases showing the same kind of injury and having the most thorough treatment resulted in the same persistent partial disability.

As in any form of surgical procedure and particularly in those in which various forms of treatment may be used, it is very important to choose the right cases of fracture for bone grafting. Naturally, it is far too early to be very positive in this matter, but it seems to us that even with the limited

number of cases which have been operated upon, certain broad rules may be laid down. As cases come under observation, they can usually be classed as early and late. The early ones being those seen within a few days or hours after injury, while the late cases, as a rule, present themselves only after some months, or else have been under continued treatment and still present disability.

In the early cases it seems probable that any of the following conditions, in the absence of contra-indications, may be sufficient cause for grafting.

1. Abnormal mobility, either lateral or anteroposterior, at the point of fracture.

2. Increasing deformity.

3. Extensive fracture of the body or any fracture of the laminae as shown by X-ray, even in the absence of either of the two other signs.

Grafting should not be performed for two or three weeks after injury in order to allow the hemorrhage to subside. It should not be done in fractures where there is a probability of crushed cord or any other extensive neurological lesion; it may, however, be done in cases where mild neurological symptoms have been present but are subsiding. Naturally, all general considerations, such as general condition, age, pulmonary disease, etc., should be taken into account, as in any major surgical operation.

Our general scheme in such early cases is, after studying the case and getting all the necessary data during the first few days after injury, to determine for or against operation. If a grafting operation is to be decided upon the patient is kept recumbent in a plaster jacket until the time of operation.

The old cases are usually seen months or even years after injury, and in them the problem is somewhat different. In these cases the patient's inability to work is the point about which the treatment hinges, and we feel that this is the most important indication for operation. Thus we have our indication in old cases for grafting as follows:

Inability to work: (a) From persistent pain at the point of injury; (b) persistent referred pain; (c) definite weakness of the back, with or without increasing deformity.

We do not feel justified in urging operation in old cases which do not show any of these symptoms. It is probable, however, that old cases with this train of symptoms will show one or more of the reasons for operation mentioned in connection with fresh fractures. If a late case has not had proper treatment, and the amount of disability and bone injury is not great, fixation in plaster or by means of a leather jacket may be advisable for some months before deciding on fixation by means of a graft. The contra-indications for grafting are essentially the same as those for fresh fractures.

*Technic.*—Little need be said in reference to the technic. The operation for fixation of the spine is well established as an operative procedure, and in these cases the usual form of the interspinous process graft was followed. It is advisable to have the groove in the spinous process deep, so as to give a



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large surface of bone for the inlay. The inlay itself should be strong. It is important the ends of the graft should lie in the spinous process and not project into the interspinous space. It is also important to so place the patient on the operating table, that the back is in a position free from strain. No attempt has been made in any of the cases to correct the position or diminish the knuckle. In the graft of the fifth lumbar vertebra the method of splitting the sacral part of the inlay was used; the two upper sacral spines were denuded on their lateral aspect, the lower part of the inlay was split by a saw cut which was placed over the sacral spines, so that one portion was on either side, a necessary procedure, as the sacral spines are too thin and too shallow to admit of splitting. This method of spinal fixation by the internal splint is not as satisfactory in the lumbosacral junction as in the lumbar and dorsolumbar spine, for the fifth lumbar spine lies so deeply, and the junction between the fifth lumbosacral makes so sharp an angle, that it is difficult to lay a well fitting and strong graft on account of this combined depth and sharp angle. Also for the reason that the spine of the fifth lumbar vertebra is very apt to be small or even rudimentary, and does not afford a sufficiently large area to insert the graft in a satisfactory manner. The patients are all kept recumbent for two months in a plaster bed or plaster jacket, previously prepared, and a plaster is worn for the next four months of ambulatory treatment.

### CONCLUSIONS

The evidence from the study of the foregoing cases is strongly in favor of early operative action. A large percentage of the cases which could be followed showed partial and even complete disability for years after the injury, many of which had prolonged mechanical treatment by fixation and support. It would seem, also, that the continuance of the mechanical support after a few months does not materially influence the result, but was of value in giving added comfort while wearing such support. This fact alone, viz., the failure of mechanical treatment, would seem to warrant active radical measures, provided the operative methods give reasonable assurance of benefit, and provided the indications for operation could be formulated. On the other hand, the results of early operative treatment, in the cases which have been watched, although not large in number, would seem to definitely indicate that early operation is a measure to be advocated in a very large number of cases. From a study of the foregoing, the writers suggest operation in the cases which show the following conditions:

1. Fresh fracture: (a) Crushed fracture of the bodies of one or more vertebræ associated with dis-alignment of fragments, particularly with involvement of any part of the laminæ; (b) fracture of the fifth lumbar, of any part, but particularly with involvement of the laminæ; (c) fracture of body showing increasing knuckle, abnormal mobility at point of fracture, or complicated with rupture of the supra- or interspinous ligaments.

2. Old fracture cases which show the persistent disability, as evidenced by inability to work, accompanied by continuance of pain, local or referred,

and with general back weakness, operation is advocated. Operation in the decade between fifty and sixty does not seem to be contra-indicated. The social position may at times have influence in directing for or against operation, for when the most rigid early care can be given, much more might be expected from early fixation treatment. Freedom from pain, however, in the early weeks of recumbent and fixation treatment, may be misleading, for it is possible, that even with the relief of all symptoms during the period of recumbency, the pain may return and cause disability when the patient becomes ambulatory and begins to use the spinal column.

One question has not been decided, viz., the extreme degree of and the persistence of the disability with simple crushed fracture of the body of the vertebra. It is possible that this may in part be due to the loosening of the anterior ligament or to the loosening of the intervertebral discs from the vertebral surface, with a rupture of the capsular ligament, and failure to firmly unite again. This seems plausible, for many of the long persistent symptoms are suggestive of a movable segment of the column. On the other hand, a very severe injury and perhaps extensive crush may result in a quicker and more complete recovery than in some of the apparently lesser ones.

#### RECORD OF INDIVIDUAL CASES

**CASE I.**—Patient aged thirty-six; occupation, housewife. Complaint, *weakness in back*. Duration two years and eight months, following automobile accident in which patient was thrown from machine, landing on back. Back is weak, tires easily after any exertion necessitating lifting or bending of back.

**Physical Examination.**—Has marked dis-alignment of spinous process of second lumbar vertebra; no abnormal mobility at point of fracture; well-defined kyphosis at second lumbar vertebra, all motions of spine guarded. No muscle spasm present; straight leg raising causes some discomfort at site of fracture.

**X-ray Examination.**—Lateral crushed fracture of second lumbar with chipping off of lumbar border of first lumbar.

**Treatment.**—Was recumbent for a short time immediately following injury; wheel chair for four months, and patient unable to stand, because of weakness and back pain. This was followed by walking on crutches for three months. Did absolutely no work for following year and three months. Back support worn for about three months in all.

**Result.**—It is now two years and eight months since the injury. The motions of the back are limited but not painful unless repeated a number of times. A distinct kyphosis is present. But weakness is so marked that she is able to do only very light housework.

**CASE II.**—Patient aged twenty-three; occupation, laborer. Complaint, *severe back pain*. Caught under falling embankment.

**Physical Examination.**—All motions of spine are limited, muscle spasm is marked, tenderness and knuckle in mid-lumbar region. Straight leg raising and thigh flexion on the right cause pain.

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*X-ray Examination.*—Crushed fracture of third lumbar. Osseous shadows in intervertebral line. No dis-alignment.

*Treatment.*—Recumbent three weeks, support four months.

*Result.*—Four months later well-defined kyphosis in lumbar region. The jacket was removed and his condition was only fair. At this time he was unable to return to work. Unfortunately he was not seen again.

CASE III.—Patient aged fifty-seven; occupation, carpenter. Complaint, *severe back pain*. Fell from scaffolding a distance of about twenty feet from ground.

*Physical Examination.*—Motions of the spine are limited. Tenderness and a well-defined knuckle are found in the region of the tenth dorsal and first and second lumbar vertebrae.

*X-ray Examination.*—Crushed fracture of the body of the first and second lumbar.

*Treatment.*—Jacket. Recumbency for one month.

*End-results.*—One year after injury walks very well. Wears leather jacket all the time except at night. Three years later: Complains of weakness of back, all motions limited. Can do no heavy lifting because of pain. Has changed occupation to one necessitating less physical strain, especially back bending and lifting.

CASE IV.—Patient aged forty-nine; occupation, brakeman. Dragged five car lengths by a freight car.

*Physical Examination.*—Swelling and tenderness over the first and second lumbar and decided limitation of all motions of back by pain. The spines of the eleventh and twelfth dorsal and first lumbar much more prominent than normal.

*X-ray Examination.*—Fracture of the second lumbar with possible fracture of spinous process of same.

*Treatment.*—Plaster eight weeks.

*Result.*—Ten years since injury. He has returned to his former occupation, which fortunately is not heavy work. A dull ache is present constantly in the back and is intensified by straining or lifting.

CASE V.—Patient aged twenty-seven, occupation, laborer. Fell about thirty feet in sitting position.

*Physical Examination.*—Pain over low lumbar region and sacrum. All motions of back are limited. Straight leg raising, both right and left, is painful. Other motions of hip are free.

*X-ray Examination.*—Marked lateral crush with rotation and dis-alignment of second lumbar vertebra.

*Treatment.*—Binder and strapping followed by a plaster jacket for a short time.

*Result.*—One year later: Did not work for six months. Working as a laborer now. Back a little stiff, but functionally very good. Eight years later: Working as a laborer, no symptoms.

CASE VI.—Patient aged thirty-two; occupation, farmer. Complaint, *pain in back*. Caught under door casing while riding through doorway on a wagon. The disability was immediate because of severe back pain.

*Physical Examination.*—Ecchymosis, tenderness and marked depres-



sion of spinous process of the eleventh dorsal vertebra. All motions of the spine are guarded because of muscle spasm and pain.

*X-ray Examination.*—Fracture of transverse process of the first lumbar with impaction into twelfth dorsal, obliteration of space between twelfth dorsal and the first lumbar.

*Treatment.*—Recumbent for a short time in a plaster jacket.

*Result.*—One year later walks well; lateral bending slightly limited to the left. Eight years later feels perfectly well. Has returned to former occupation.

CASE VII.—Patient aged twenty-eight; occupation, operator. Complaint, *pain in low back, inability to work*. Three years ago patient jumped four stories from burning building. Severe pain and back weakness, aggravated by standing for any length of time or bending back. Back feels stiff.

*Physical Examination.*—Marked kyphosis beginning at tenth dorsal and extending to first lumbar. Increased mobility at point of deformity. Flexion and lateral bending are fairly free. Backward bending very much limited.

*X-ray Examination.*—Crushed fracture of second lumbar.

*Treatment.*—Short recumbency and fixation with plaster jacket for eight months following.

*Result.*—Continued disability at last report.

CASE VIII.—Patient aged twenty-five; occupation, engineer. Complaint, *low back pain, local, and referred to lower abdomen and leg. Back weakness, inability to work*. Caught under falling embankment. Disability complete from beginning because of pain.

*Physical Examination.*—All motions of spine limited by pain.

*Treatment.*—Plaster jacket two years; leather jacket two years.

*Result.*—Pain on motion persisted for years. Recovery was complete in five years for light and possibly for heavy work. At present work, sedentary, patient well and comfortable.

CASE IX.—Patient aged forty; occupation, laborer. Complaint, *pain in lower dorsal region. Inability to work because of it*. Duration four years and seven months. Four years and seven months ago fell from third-story window. He was immediately disabled because of back pain. Constant pain in low dorsal region has persisted. It is worse when stooping, lifting or turning in bed. Has not been able to work, although it has been attempted several times since injury.

*Physical Examination.*—Distinct kyphosis in low dorsal region. All motions of back very much limited by pain. Straight leg raising limited on both sides but more so on left. Forced flexion of thigh on abdomen, especially left, very painful.

*X-ray Examination.*—Crushed fracture of the first lumbar vertebra.

*Treatment.*—Back strapping and thirteen days recumbency at the time of injury.

*Result.*—Total disability at present time.

CASE X.—Patient aged thirty; occupation, laborer. Complaint, *pain in lumbar region for past five years*. Five years ago, while working as laborer was caught under falling embankment. Disability was im-

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mediate. Pain on lifting or stooping so severe that it is disabling if continued for any length of time. The pain is not referred.

*Physical Examination.*—Small kyphosis at first lumbar vertebra. Motions of back fairly free. Very marked abnormal mobility at point of deformity.

*X-ray Examination.*—Crushed fracture of first lumbar.

*Treatment.*—In bed for five months without fixation.

*Result.*—Was completely disabled for three years. Two years ago he began light work which he has continued to do a part of the time with more or less discomfort.

CASE XI.—Patient aged thirty-five; occupation, fireman. Complaint, *pain in back and referred, and feeling as though back was giving way*. He fell down a twenty-foot embankment. Disability was immediate because of pain localized in low back.

*Physical Examination.*—Tender prominence of spine of the tenth, eleventh, and twelfth dorsal and first lumbar vertebrae. Some muscle spasm is present. All motions of the back are restricted. Inability to work on account of pain. Is working at occupation requiring no strain (flagman).

*X-ray Examination.*—Crush of body of eleventh dorsal vertebra.

*Treatment.*—Recumbent for two weeks and after one month mechanical support, which is still worn, four years after injury.

CASE XII.—Patient aged forty; occupation, laborer. Complaint, *disabling pain in back*. Patient was brought to hospital in an intoxicated condition. Complained of indefinite pain in back.

*Physical Examination.*—Swelling and slight ecchymosis over low dorsal region. Tenderness marked, all motions of the spine limited.

*X-ray Examination.*—Lateral crush and dis-alignment of the tenth dorsal with preservation of intravertebral spaces.

*Treatment.*—Recumbent one month.

*Result.*—Disappeared.

CASE XIII.—Patient aged thirty-six; occupation, laborer. Fell twenty feet, landing on feet. Disability was immediate. Back pain was very severe and intensified by motion.

*Physical Examination.*—Seeming depression of the spine of the twelfth dorsal vertebra. A large ecchymosis in this region. Tenderness marked and all motions of spine guarded.

*X-ray Examination.*—Fracture of body of twelfth dorsal vertebra with dis-alignment.

*Treatment.*—Plaster jacket and rest in bed for a month.

*Result.*—Pain still present seven months after injury in dorso-lumbar region. Motions of the back were limited and painful. Leather jacket was advised but the patient did not return and was lost sight of.

CASE XIV.—Patient aged thirty-four; occupation, brakeman. Struck by train and knocked down, but after a short time he walked to his home, which was a short distance away. Pain in dorsal region was constant and intensified by any movements of the back.

*Physical Examination.*—A distinct kyphosis present, extending from

the eighth to the tenth dorsal vertebræ. All motions of the back are limited by pain. Tenderness over the deformity marked.

*X-ray Examination.*—Compression fracture of the bodies and laminae of the ninth and tenth dorsal vertebræ with considerable displacement.

*Treatment.*—Recumbent two months, followed by fixation with plaster casts and leather jacket.

*Result.*—At present time, two years since injury, still wearing jacket during day. Has had to take up lighter work. Pain is constant. He can do no lifting or anything that requires bending the back; marked kyphos at ninth and tenth dorsal vertebræ; marked tenderness over the deformity, and limitation of all motions of the spine. Practically almost entire incapacity.

CASE XV.—Patient aged thirty-eight; occupation, lineman. Complaint, *dull aching pain and tenderness in back*. Fell twenty-five feet from a pole eight months ago, at which time patient fractured surgical neck of right humerus and injured back. Considerable pain was present in back at time, but it was not treated. Pain persisted, and two months later fracture was diagnosed by X-ray, and plaster jacket applied.

*X-ray Examination.*—Crushed fracture of twelfth dorsal vertebra.

*Treatment.*—After two months plaster jacket support still worn.

*Result.*—It is now eight months since injury. Patient is wearing jacket and unable to work. All motions are limited by pain; a distinct kyphos is present in the low dorsal region. Pain on standing if jacket is not worn.

CASE XVI.—Patient aged forty-seven; occupation, nurse. Complaint, *pain in low dorsal region*. Thrown from automobile. Disability was immediate because of pain in back, inability to stand or sit.

*Physical Examination.*—Increased prominence of the spine of the ninth dorsal vertebra. All motions limited, very marked pain in back and referred to abdomen.

*X-ray Examination.*—Crush of ninth dorsal vertebra.

*Treatment.*—Recumbent in plaster jacket for eight weeks, and mechanical support for four years.

*Result.*—At present time, five years after injury, still has considerable pain in back. All back motions are restricted and painful and patient has been forced to take up lighter work, and is still obliged to wear light support.

CASE XVII.—Patient aged forty-five; occupation, brakeman. Complaint, *pain in back*. Fell while climbing from tender of engine to first car. Was unconscious for a time, but when consciousness was regained he could not walk because of pain in back.

*Physical Examination.*—A rounded kyphos extends from the twelfth dorsal vertebra to the first lumbar. All motions of the spine somewhat restricted.

*X-ray Examination.*—Crushed fracture of the body of the twelfth dorsal vertebra.

*Treatment.*—Recumbency, followed by plaster jacket for several months, followed by a leather jacket which is being worn a part of



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the time at present, six years after the injury. After four years of disability he returned to a similar but lighter work.

CASE XVIII.—Patient aged forty-nine, occupation, laborer. Injured by being crushed between top of elevator and roof of shaft.

*Physical Examination.*—Obliteration of vertebral sulcus; abnormal mobility at point of fracture and kyphos at the twelfth dorsal vertebra. Pain not prominent feature.

*X-ray Examination.*—Crushed fracture of twelfth dorsal vertebra.

*Treatment.*—Plaster and recumbency. Still in recumbent treatment.

CASE XIX.—Patient aged twenty; occupation, iron worker. Complaint, fell sixty feet, unconscious several hours. Severe pain in low dorsal region extending through the abdomen, aggravated by any motion of back, or coughing, or sneezing.

*Physical Examination.*—Definite kyphos at eleventh dorsal, and obliteration of the vertebral sulcus. No dis-alignment of spinous processes or abnormal mobility at point of fracture. All motions of spine limited by pain. Referred abdominal pain. Straight leg raising is limited equally on both sides.

*X-ray Examination.*—Crushed fracture of eleventh dorsal vertebra.

*Treatment.*—Short recumbency and fixation with plaster jacket followed by bone graft operation.

*Result.*—This case is too recent a case to give result at this time, but at present (five months) he is active and free from pain.

CASE XX.—Patient aged twenty-nine; occupation, housewife. Complaint, fell off roof, striking on back on ground about eight feet below. Pain was severe, but could walk into house. Pain on any motion of jarring was much more severe upon entrance to hospital a few hours later than immediately after accident.

*Physical Examination.*—Knuckle in low dorsal region. There is some dis-alignment of spinous process of the eleventh dorsal vertebra. No abnormal mobility at point of fracture can be demonstrated. The normal vertebral sulcus has disappeared. Hip motions and straight leg raising were painful; very marked referred abdominal pain.

*X-ray Examination.*—Crushed fracture eleventh dorsal.

*Treatment.*—Recumbency in plaster for one month. Bone graft, recumbent two months.

*Result.*—Now, eight months since the operation, the patient is active, doing own housework, no pain nor disability. Is still wearing support occasionally as precaution.

CASE XXI.—Patient aged twenty-seven; occupation, laborer. Complaint, pain in lumbar region for six weeks duration, aggravated by walking, lifting, or bending. Fell fifteen feet six weeks ago, landing on back on concrete floor. Disability was immediate because of pain which was entirely local.

*Physical Examination.*—Flexion and extension of spine limited, but lateral bending is fairly free. There is a well-defined kyphosis in the region of the first lumbar vertebra.

*X-ray Examination.*—Lateral crush and dis-alignment of the first lumbar vertebra.

*Treatment.*—Recumbent for three weeks on Bradford frame, followed by bone graft and two months recumbency in jacket, and later ambulatory with jacket.

*Result.*—Seven months following operation is active with perfect comfort. A plaster jacket is being worn at present.

CASE XXII.—Patient aged twenty-eight; occupation, lineman. Complaint, *pain in lumbar region radiating to left leg*. Six weeks ago fell thirty feet, striking on back. Disability was immediate because of back pain. Remained recumbent in hospital one week and was discharged, still complaining somewhat of pain. Three weeks following discharge, returned, seeking relief from pain which patient says is growing worse. He is unable to remain recumbent on back, but can rest comfortably on side for a time. Pain is relieved somewhat by walking.

*Physical Examination.*—There is a marked kyphosis over the third and fourth and fifth lumbar vertebræ. Muscle spasm present. All motions of spine very much limited. Hyperextension and straight leg raising of left leg cause severe pain which radiates down left thigh.

*X-ray Examination.*—Crushed fracture of second lumbar vertebra.

*Treatment.*—Bone graft, three months following injury.

*Result.*—Relief of pain was almost immediate following operation. Six months later he had returned to work as a lineman. Support was worn for ten months during work. The motions of spine are fairly free, there has been no increase in deformity and he is free from pain at present, twenty-two months after operation.

CASE XXIII.—Patient aged forty-nine; occupation, cement finisher. Complaint, *pain in back and right hip*. One year and nine months ago fell from a scaffolding about fifty feet high, striking on back. Disability was immediate because of pain in low back and right hip. Was in hospital for four weeks; since then has been treated by strapping, plaster jackets, leather jackets, wearing belts; mechanohydrotherapy. The most relief came from back strapping. The pain in low back and right hip is brought on by walking, stooping, or lightest kind of work.

*Physical Examination.*—There is a depression between the third and fourth lumbar vertebræ, with deviation of the spinous process of second lumbar vertebra to the left. All motions of spine limited, lateral motion limited to right less than to left. Muscle spasm in lumbar region is marked. Abduction, adduction, internal rotation, and hyperextension of right hip cause pain referred to low back region. Straight leg raising is limited equally on the two sides by pain referred to the low back.

*X-ray Examination.*—A lateral crushed fracture of the first lumbar vertebra.

*Treatment.*—One year and nine months after injury, bone graft extending from the eleventh dorsal to the third lumbar, followed by recumbency for four months in plaster jacket.

*Result.*—Eight months after operation entirely free from pain. His back allows forty degrees forward bending, and twenty degrees lateral



FIG. 1.—Case II. Shows but small amount of injury by X-ray, but symptoms pronounced, and an increasing deformity, two bodies being involved in an injury of lesser degree.

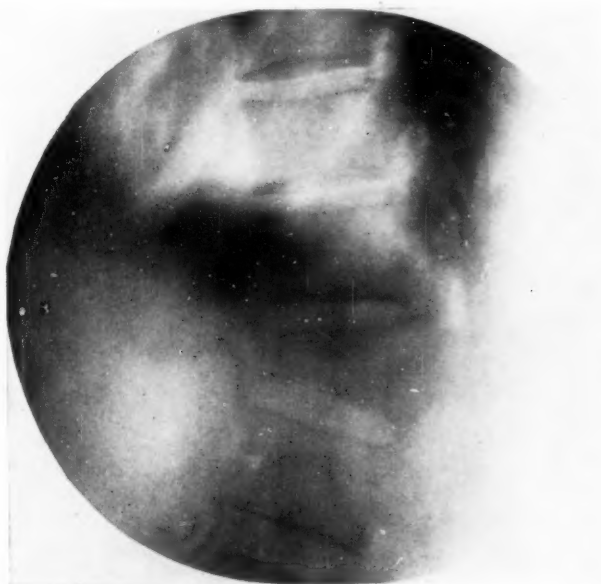


FIG. 2.—Case III. Compare with Fig. 3. The adjacent vertebra evidently involved. Lateral crush, slight or none, yet disability still exists.

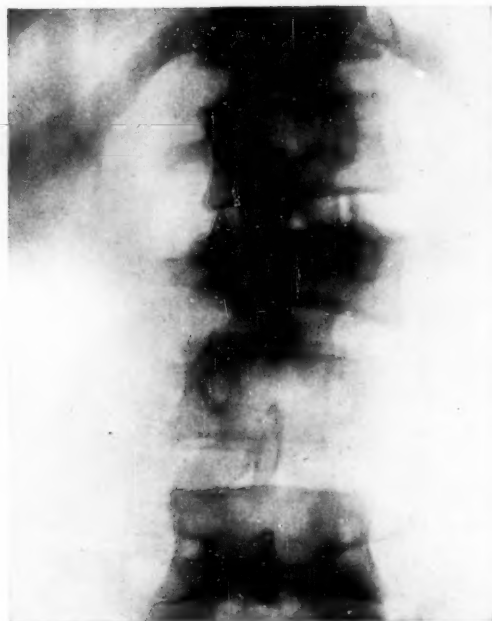


FIG. 3.—Case V. Shows severe crush, but apparently confined to the one body, which gives better opportunity of union. With indifferent treatment, this case made a good recovery.



FIG. 4.—Case XIV. A severe injury of the combined type of anteroposterior and lateral. The latter element endangers the integrity of the laminae.



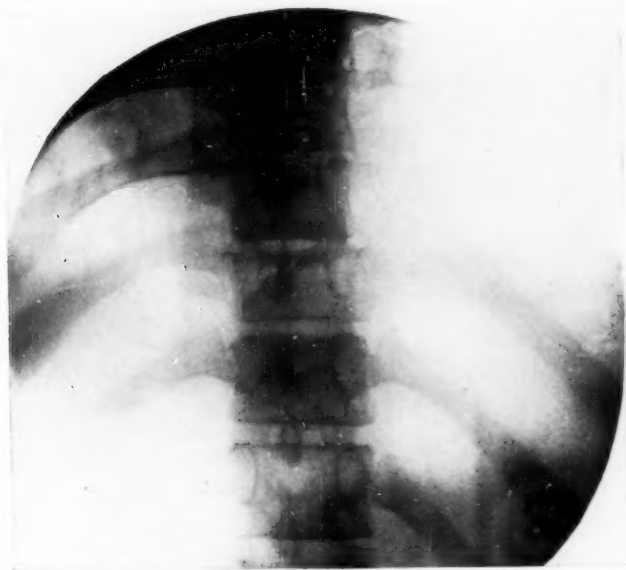


FIG. 5.—Case XX. Shows the considerable degree of disalignment in an injury in which there was very little anteroposterior crush. Pain particularly referred was very prominent—always a suggestive feature of this kind of injury.

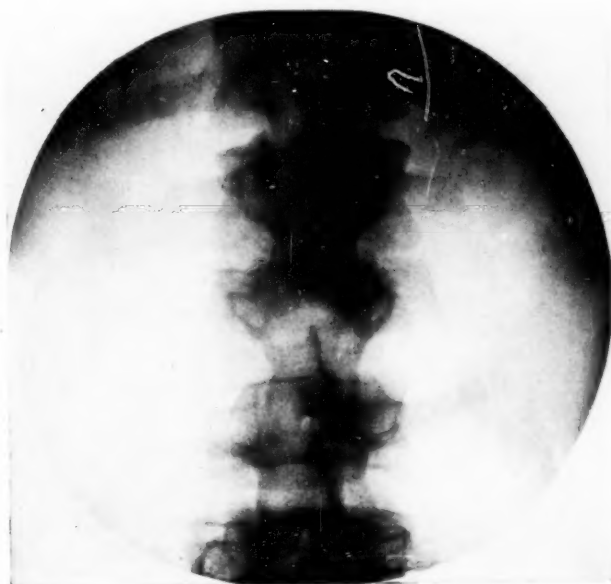


FIG. 6.—Case XXII. Shows only slight disalignment in a severe anteroposterior crush.

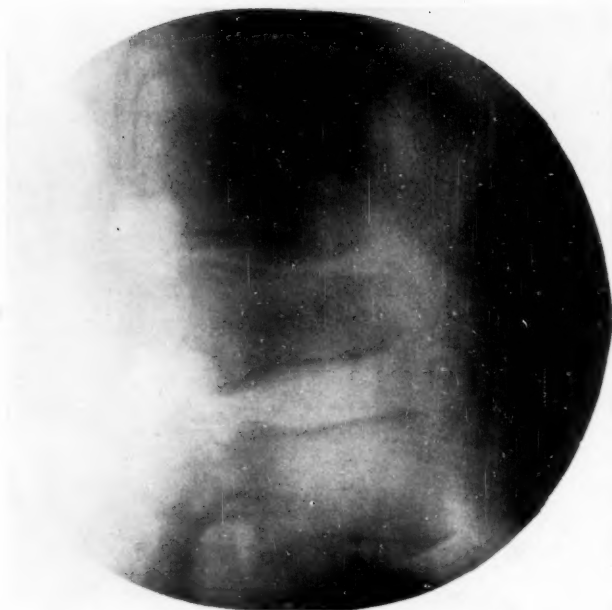


FIG. 7.—Case XXII. Shows marked anteroposterior crush, probably involving body above. The injured interposed intervertebral disc undoubtedly prevents the firm union between the two surfaces of injured bone.

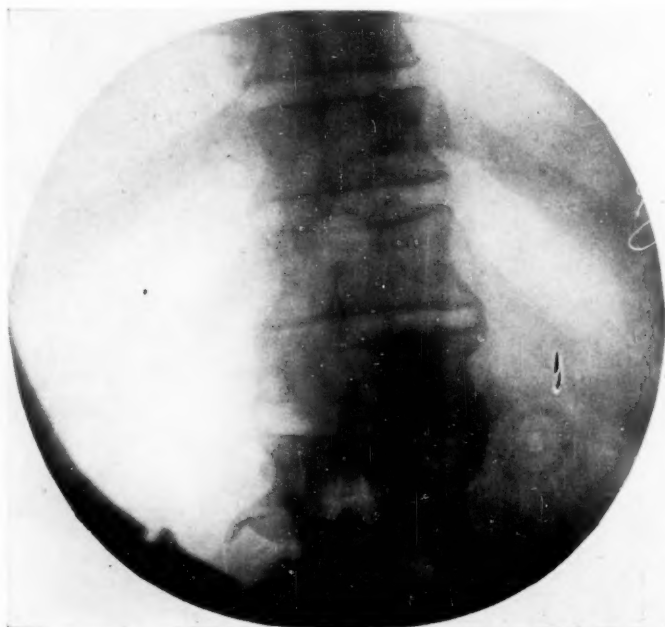


FIG. 8.—Case XXIII. Lateral crush. Shows condition at period remote from time of injury. Bone over growth more pronounced in region of injury suggests natural attempt for protection.

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bending, and he is able to do light work. This case was complicated by hypertrophic arthritis of the spine.

CASE XXIV.—Patient aged thirty-six; occupation, machine operator. Complaint, *pain in left leg and low back*. One year ago patient was dragged between rollers of mangle which were about ten inches apart. Entire body went through, head first. Disability was not immediate, was able to walk to street car. In bed two weeks; two weeks later (four weeks after injury) returned to work. Worked for three months when pain in back reappeared, it was localized in the low back and constant. Two months later pain became so severe that patient was forced to give up work. He was treated by local physician four months before entrance to the clinic. Walking about seems to relieve patient somewhat, it being described by the patient as endurable only when walking. He is unable to lie on back or left side because of great discomfort.

*Physical Examination.*—There is a marked list to the left. The lumbar lordosis obliterated. Tenderness is extreme over fourth and fifth lumbar spinous processes. Bending forward, backward and toward the left cause severe pain. Straight leg raising is limited on both sides equally.

*X-ray Examination.*—Crushed fracture of the fifth lumbar vertebra with dis-alignment.

*Treatment.*—Recumbent two weeks, at home, medication, etc., strapping and casts for four months without relief. Bone graft extending from the third lumbar to second sacral vertebrae. Spinous processes of the sacral vertebra are so small that graft was split so as to straddle them instead of the usual technic.

*Result.*—Wearing leather jacket at present, thirteen months since operation. No pain; is doing light work.

CASE XXV.—Patient aged twenty-eight; occupation, brakeman. Complaint, *pain in back and leg, disability complete*. January 10, 1916, patient was caught between freight cars; not much discomfort after being extricated until twenty minutes later, when he started to pull a switch, and suddenly fell and became unconscious. Pain is severe in low back, inability to lie on left side.

*Physical Examination.*—Muscle spasm increased by motion. Tenderness extends from the first lumbar to the fifth, is most marked over spine of the fifth. All motions of the back cause severe pain which is referred to the region of the fifth lumbar vertebra. Adduction, abduction, straight leg raising to 40 degrees, hyperextension of the right thigh cause pain referred to the fifth lumbar. All motions of the left hip are painful except rotation.

*X-ray Examination.*—Distinct crack in lamina and dis-alignment; question of crush of body of fifth.

*Treatment.*—Bone graft operation seventeen days following injury.

*Result.*—Support was worn for eight weeks only. Patient felt so well that he removed support at end of ten weeks, and in three months had resumed his regular occupation.

CASE XXVI.—Patient aged thirty-five; occupation, stone mason.

Complaint, *pain and weakness in back*. One month ago fell sixteen feet, striking flat on back on floor; could not walk, but crawled thirty feet to a spot where he spent the night prone. Pain was very severe and constant in low back. Increased by any motion of the back.

*Physical Examination*.—A gap is easily felt between spines of the twelfth dorsal and first lumbar. Hyperextension of spine causes pain and increases the muscle spasm. All motions of upper lumbar and lower dorsal spine are limited. Straight leg raising right or left to ninety degrees does not cause pain.

*X-ray Examination*.—Crushed fracture of body of the first lumbar.

*Treatment*.—Bone graft.

*Result*.—It is now eleven months since operation and patient is very comfortable and is able to work. Has been working for six months; motions of back fairly free and not painful.

CASE XXVII.—Patient aged twenty-six; occupation, baker. Complaint, *pain and weakness in back*. Four and a half months ago fell forty-five feet, injuring back and fracturing right ankle. About two months later patient noticed kyphos which he thinks is increasing.

*Physical Examination*.—Kyphos at tenth or twelfth dorsal vertebra. All motions of back limited by pain.

*X-ray Examination*.—Compression fracture of the first lumbar.

*Treatment*.—Bone graft operation. Great difficulty was found in incorporating spines of the first and second lumbar vertebrae in graft because of their rotation to the left.

*Result*.—Eleven months after operation had no discomfort, and was working. A light back brace was being worn at this time.



## SURGERY OF SPASTIC PARALYSIS

BY A. BRUCE GILL, M.D.

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SPASTIC paralysis of infancy and childhood is a common affection, and its treatment has been more or less unsatisfactory. While the orthopædic treatment of anterior poliomyelitis has become quite definite and well established, and is productive of splendid results; the treatment of spastic paralysis has been comparatively neglected, and it remains more or less obscure and unsettled, and its results are uncertain.

Tubby and Jones collected 837 cases, of which 510 were hemiplegic, 157 diplegic, 140 paraplegic, and 30 monoplegic. The paralysis may be of intra-uterine origin, due to cerebral defects, hemorrhage and softening, syphilis, specific fevers, eclampsia and convulsions, etc.; or it may be due to injuries to the head during birth; or, finally, it may be acquired after birth from hemorrhage, chronic meningitis, hydrocephalus, etc. It is common in children of premature birth. Thus, it is seen there is a wide variety of causes of spastic paralysis, and according to the degree of injury or lack of development of the brain or the spinal cord there is a wide divergence in the extent and degree of the spasticity and weakness. Unfortunately, many children with spastic paralysis are mentally subnormal or even idiotic. This renders the prognosis more unfavorable and the treatment more difficult.

I shall not take the time to consider the various forms and the symptoms of this affection. Suffice it to say that they are dependent upon the distribution and degree of spasticity and weakness and upon the mental characteristics.

Nor shall I here discuss what cases are unsuitable and what ones suitable for treatment, nor the indications for and the methods of conservative treatment; but shall speak briefly of the various operative measures that have been employed to improve the condition of these patients.

Tenotomy of the contracted muscles is the oldest and the most commonly employed surgical procedure for the relief of spastic paralysis. This permits the limb to assume a normal position. It has two values; it relieves the weak opposing muscles from constant overstretching, and it breaks the vicious circle formed by tendon, afferent sensory nerves, spinal centre, efferent motor nerves, and muscle. If the weak muscles, which are the opponents of the strong contracted muscles, are relieved from the strain of overstretching, they will in a measure recover their strength and be better able to resist the pull of their strong opponents which are temporarily disabled by tenotomy and which will for some time be partially handicapped mechanically by the lengthening which they have suffered. In the second con-

sideration, it would appear that the tension of a muscle is somewhat dependent upon the tension of its tendon. If pull is made upon the tendon of a muscle a message is carried by sensory nerves to the spinal centre, whence an efferent impulse is sent out to the muscle which causes it to contract to resist the tension upon its tendon. Normally such impulses are controlled by the cerebral centres, but in spastic paralysis the cerebral centres have been disconnected from the spinal centres, have lost their control, and can no longer inhibit the excitability of the peripheral arc. Therefore the peripheral arc remains in a constant state of over-sensitiveness and over-excitability. This is manifested in the contracted muscles and the exaggerated reflexes. The tenotomy of a tendon cuts this arc, or circle, at one point, and breaks the stream of afferent impulses that were constantly pouring in upon the spinal centres. The centres, therefore, quiet down, and in their part cease to send forth the continuous stream of efferent impulses to the muscles that kept them in a state of constant contraction.

Unfortunately, tenotomy of contracted muscle tendons has not proved uniformly successful in practice. In many cases there has been a recurrence of the original condition. In numerous other cases an opposite deformity has been produced. A talipes equinus has been converted, for example, into a talipes calcaneus, which is a more disabling deformity.

Therefore, Foerster proposed and executed his posterior spinal root resection. This operation cuts the vicious circle by dividing the sensory nerves just before they reach the spinal centres. This surgical procedure is, however, so difficult and severe as to preclude its common use.

Stoeffel then attacked the problem in a different manner. He pointed to the fact that in spastic paralysis all muscles are alike spastic; and that, for example, in talipes equinus the anterior leg muscles are spastic as well as the posterior muscles, but that the latter are so much stronger they overpower the former. The anterior muscles are overstrained and over-stretched and thus become definitely weakened. This weakness is not a real paralysis. In fact, in spastic paralysis there is no absolute paralysis. In the second place, tendons that often appear contractured are not really so. The muscles are shortened only by spastic contraction that disappears under ether. No real muscle shortening is present. Therefore a tenotomy lengthens a muscle which is not shortened and permits the development of an opposite deformity. If contracture persists under a general anaesthetic it is permanent, and the tendon should be lengthened. Stoeffel therefore proposed to weaken the strong muscles by a surgical procedure and to strengthen the weak muscles by freedom from overstrain and by exercise. Thus he would establish an equilibrium of flexors and extensors, for example, that would maintain the limb in normal position and allow more or less normal function. He weakens the strong contractured muscles by resecting a portion of their motor nerve supply.

To correct talipes equinus the internal popliteal nerve is exposed in the popliteal space. It is dissected into numerous bundles which are found

## SURGERY OF SPASTIC PARALYSIS

to supply the various muscles of the calf of the leg. A portion of each bundle supplying a spastic contracted muscle is then excised for a length of one to two inches. Approximately one-fourth to two-thirds or three-fourths of the nerve supply to a muscle is thus resected, depending on the amount of spasticity and deformity present in each case. The electrode is used in distinguishing the nerve-bundles which supply the various muscles, except when the surgeon's knowledge of the anatomy of the nerves enables him to dispense with its assistance.

For contracture of the hamstring muscles, operation is performed upon the sciatic nerve in the upper part of the thigh. For adductor spasm one or both branches of the obturator nerve are excised. In the upper extremity the median nerve is exposed in the flexure of the elbow and the branch going to the pronator radii teres and the branches to the various flexor muscles of wrist and fingers are resected as desired.

During the last four years the author has performed thirty-five Stoffel operations on the popliteal, the sciatic, the obturator, and the median nerves. A complete report of these cases will be published later. The results have been so satisfactory that the operations have been done routinely in the author's orthopaedic services at the Episcopal and the Presbyterian Hospitals and in Doctor Ashhurst's service at the Orthopaedic Hospital.

The following cases illustrate briefly the results that have been obtained:

CASE I.—C. C. *Spastic paraplegia since birth.* September 14, 1914: Is able to walk with the greatest difficulty. September 26, 1914: Operation upon both obturator and both internal popliteal nerves. April 25, 1915: Able to walk fairly well. Heels come to the floor, but toes strike the ground first. October 19, 1915: Second operation upon both popliteal nerves. January 18, 1916: Heels on the floor in walking. Walks much better.

CASE II.—E. M. *Spastic hemiplegia.* July 20, 1915: Marked flexion of right wrist and fingers. Foot in marked equinus, walks on toes. July 21, 1915: Operation on right popliteal nerve. At the same time the tendo Achillis was tenotomized and the extensor proprius hallucis was transplanted to the head of the first metatarsal. All the flexor tendons of the right wrist were lengthened. December 1, 1917: Walks well, with but slight limp. Foot is straight and firm on the floor in walking. Right hand is markedly flexed at the wrist and the fingers partially flexed in the palm. A Stoeffel operation will now be performed on the median nerve as the tendon lengthening has not cured her deformity.

CASE III.—W. G. *Spastic hemiplegia.* November 1, 1914: Left arm—forearm pronated, wrist flexed, fingers and thumb flexed into palm. No active extension of wrist, slight motion of fingers but none of thumb except slight adduction and flexion. Left leg—walks on toes, no active motion in ankle, tendo Achillis contracted, hollow-foot, hammer-toe. November 4, 1914: Operation on median and internal popliteal nerves, tenotomy of tendo Achillis, and transplantation of

extensor proprius hallucis to the first metatarsal. December 7, 1914: Wrist, fingers, and thumb are straight. May 10, 1915: Can actively extend fingers almost to normal limit, can make good fist, can move wrist feebly. No active supination. September 13, 1915: Good grip, slight control of thumb. Can hold objects in his hand.

CASE IV.—R. J. February 26, 1914: Walks on toes with legs crossed, very unstable. October 2, 1914: Operation on both obturators and internal popliteal. January 9, 1915: Much improved, heels on ground when walking, legs straight, does not drag toes. Walks with braces.

CASE V.—C. J. March 20, 1915: *Contracture of tendo Achillis, ankle and patellar clonus*. March 24, 1915: Operation, partial resection of nerve supply to gastrocnemius, soleus, and peronei. May 1, 1915: Foot in good position. Can dorsiflex foot well. Much improved in walking.

These cases, which are but a few of those operated upon, illustrate the improvement which occurs after nerve resection. In several instances a second operation was performed, when it was found that too little of the nerve supply had been resected at the first operation. It is better to resect too little than too much. In operations upon the lower extremity the results have appeared to be almost uniformly successful and satisfactory. In resections of the median nerve of the arm the results are not functionally so good, although the cosmetic results are satisfactory.

Following operation the after-treatment should be thorough and persistent in educating the weakened muscles and in securing coördination. Unfortunately, the mental condition of the patients and the lack of proper facilities for the work interfere greatly with the training. Notwithstanding these difficulties, the Stoeffel operation appears to the writer to afford the best solution yet offered for these cases.

It may be mentioned that tendon transplantations, especially in the arm, may be productive of more or less improvement. Nutt's operation of intraparineural neurotomy with immediate re-suture has also been performed with success.

The writer has considered a modification of the Stoeffel operation—instead of partial nerve resection, he proposes a transplantation of the same nerves into the weak opposing muscles. Anatomical difficulties would not permit of the universal application of this procedure.

It would be interesting to know what occurs in the muscles following the Stoeffel operation. Part of the nerve supply of the muscle has been removed and a portion of the muscle paralyzed. It seems probable that in time the remaining nerves will neurotize the entire muscle. Only time will tell whether the good results of the operation will be permanent.

Sharpe's cerebral decompression for spastic paralysis is on trial, but it would appear to be of value only in recent cases, and particularly in the new-born.



## CONTRACTURE OF THE BLADDER (HYPERTONIA VESICÆ) DUE TO SPINAL INJURY

By MARTIN W. WARE, M.D.  
OF NEW YORK

THIS report of an isolated case of a spinal fracture cured by laminectomy is not submitted under cover of a plea for operative interference, but rather to direct attention to the unusual and somewhat exceptional features that characterize it; to emphasize the value of X-rays in localization, and, finally, by the corroboration of findings at operation, to add to our understanding of spinal cord localization. The history follows:

On January 5, 1917, I was requested by Dr. P. L. to see a man, aged forty-five years, who was suffering pain—a severe hemorrhagic cystitis, great frequency and tenesmus with marked pain in the left lumbar region; temperature  $102^{\circ}$ , sweat and much loss of weight.

*Past History.*—On November 9, 1916, he fell from a ladder at a height of 30 feet, sustaining a fracture of both ankles, for which he was removed to a city hospital six hours later. Not having voided the following morning, he was catheterized. Thereafter catheterized *t.i.d.* for six weeks (retention).

No paralysis of the limbs developed; X-ray failed to show injury of the spine. In the meantime, the fractures of both ankles healed kindly in the plaster case. Retention of the urine gave way to repeated frequent urination approaching almost constant dribbling. (True incontinence, no ardor urinæ. Automatic emptying of the bladder.)

*Examination.*—Patient found greatly emaciated; temperature  $102^{\circ}$ ; pulse, 102, chill having preceded. The glans penis was eroded and all the skin about much macerated from the escaping foul-smelling urine. The urine painfully voided was mixed with pus and blood; finger in the rectum caused a gush of urine (automatic). The bladder was found very tender by rectum as well as over the suprapubic region. Tenderness extended along the course of the left ureter to the left kidney (ascending infection?). All the muscles of the left half of the abdomen and lumbar region likewise were spastic. No anæsthesia nor paralysis of the limbs nor loss of any of the reflexes was to be made out at this examination. The possibility of a spinal fracture was entertained none the less to account for the *assumed isolated disturbance of the bladder mechanism*, but the septic condition of the patient demanded treatment of the urinary tract first.

On January 6, 1917, the patient entered the hospital. Permanent catheter was attempted but not tolerated. For a few days, bladder irrigation. As this also taxed the patient and all the symptoms persisted with the addition of calcareous particles, and the patient was losing rapidly in weight, a refinement of diagnosis (pyelitis?) with the cystoscope was attempted. This proved a failure, for the bladder capacity was barely 30 c.c. (contracture). The day following suprapubic cystotomy under general anæsthesia was performed. It was a difficult operation; the peritoneal fold having been drawn far beneath the pubic arch, the abdominal cavity was accidentally entered. This rent

was sutured, at the same time the peritoneum was secured at a higher level of the bladder. The bladder when entered was found to admit the index finger and permitted scantiest excursion of it (contracture). No projection of prostate nor calculus nor ulcer, but the bladder wall was fully  $\frac{1}{2}$  inch thick (hypertonic). Rubber drain into the bladder. Immediately following the operation, improvement of the general condition set in. At the end of two weeks, urine cleared and the drain was removed. After an interval of another week, the wound having contracted, an indwelling catheter was tried to bring about complete closure. This was effected in another week. Now, however, the patient could not retain even the smallest quantity of urine for any length of time (hypertonic) and during this period, in sleep, was incontinent. At times voluntary urination of small quantities was possible. Following such, catheter found the bladder empty. Urine continued clear and urination was no longer a painful act. Bladder could be distended to 60 c.c.

Now four weeks after operation, the patient was out of bed, able to walk and gained considerable in weight. Attention was again directed to the possibility of spinal injury. A marked tenderness over the dorsolumbar region of the left side, also a slight kyphosis taking in the last dorsal and upper lumbar vertebræ was made out. A very small butterfly-shaped area of anæsthesia in the anal fold extending forward to the scrotum was mapped out. No dissociation of heat and pain sensation. Dr. George Jacoby corroborated these findings and added the absence of the cremaster reflex and slightly increased left patellar and left abdominal reflexes. Doctor Jacoby concurred in the diagnosis of spinal pressure from bone injury dating back to the accident. The X-rays, particularly the lateral view, taking in the lower dorsal lumbar region, showed a compression fracture of the body of the twelfth dorsal and first lumbar vertebræ.<sup>1</sup> Doctor Jacoby like myself advised operation for the possible relief of pressure, i.e., decompression to offset and minimize later secondary degenerative changes of the cord. As yet no evidence of the latter had shown themselves, such as spastic contractures or increased reflexes.

*Operation* (February 3, 1917).—Under general anæsthesia. Laminectomy. The spinous processes and the laminæ of the twelfth dorsal and first, second, and third lumbar were removed down to the articular processes. Pulsation of the cord perceptible through the dura. Upon palpation a tense band was felt over the lower part of the exposed dura. Dura incised between two guide sutures. No undue amount of fluid escaped nor evidence of any blood discoloring the same. The opening of the dura was enlarged up and down bluntly. The cord was now seen to be "angulated," corresponding to the altered position of the fractured vertebræ. The height of the angle was at the level of the first and second lumbar vertebræ, corresponding in the cord to the location of the conus. No hemorrhages in the cord. The vessels of the pia, normal. At the location of the band referred to above a

<sup>1</sup> Doctor Caldwell reports: The X-ray plates show a pathological condition in the dorsolumbar region. Apparently the body of the first lumbar vertebra has been crushed into a wedge-shaped mass, the apex forward making a kyphosis at this point.

## CONTRACTURE OF THE BLADDER

number of fine adhesions passed between the dura and the cord. These were separated by a probe which could be passed freely upward and downward along the cauda. The anterior surface of the cord explored with the probe. No injury to the nerve roots encountered. No loose fragments of bone found; only the displaced bodies of the vertebrae above referred to.

It was now evident that resuturing of the dura would subject the cauda to pressure again, since the latter protruded beyond the slit in the dura. Therefore a fascial graft from the fascia of the dorsal muscles  $1\frac{1}{2} \times \frac{1}{2}$  inches was interposed, sutured in place with fine silk, smooth side of the graft facing the cauda. Fluid from the cord no longer escaped. Slight troublesome hemorrhage from the bone was controlled with bonewax. Muscles sutured in layers, then the fascia and finally the skin. Operation lasted forty-five minutes.

*Postoperative Course.*—No more dribbling or incontinence for retention now set in, therefore catheter, *b.i.d.* On the third day suprapubic wound opened, because of retention. From now on, daily bladder irrigations till the urine began to clear. At times the patient manages to void one or two ounces per urethram. At the end of four weeks after the operation, patient discharged, able to walk freely and to void small quantities of urine—three ounces. At no time after operation was there any paralysis of the limbs or the rectum, nor any undue abdominal distention. Improvement of the bladder function progressed steadily. One year later, complete return of urinary function has set in. At no time was sexual function in abeyance, and it is normal now.

*Summary.*—Dysuria was in the foreground, but it was only an incident of the actual condition, and its underlying cause—the spinal fracture—escaped early detection because the early radiograms did not take in the level at which the fracture was located, as did the later radiograms by Doctor Caldwell. All of the phases of dysuria were exhibited in a most exemplary manner, characteristic of spinal cord injury, and their sequence for that reason is bracketed in the history. First there was (atony) attended with “retention” incontinence of overflow. This gave way to “true incontinence” (without ardor urinæ), the so-called “automatic emptying of the bladder,” and finally there was the hypertonic bladder. It was in the latter stage, I first saw the patient.

Characteristics of hypertonia were: intolerance of all instruments and their repulsion when introduced, and the gush of the small quantity of urine when the finger was inserted in the rectum. At operation, the bladder wall was found in contracture, its walls  $\frac{1}{2}$  inch thick and its capacity barely 30 c.c., admitted merely the index finger. Operation relieved all urinary disturbances. The exquisite localization of the lesion in the conus and the isolated and exclusive vesical disturbance establish beyond any doubt that bladder innervation centres in the conus.

The use of fascial grafts to bridge over the gap in the dura, preventing escape of cerebro-spinal fluid and obviating further adhesions or compression of the spinal cord, was most successful.

## LOOSE CARTILAGE IN THE TEMPOROMAXILLARY JOINT

SUBLUXATION OF THE INFERIOR MAXILLA

BY RICHARD J. BEHAN, M.D.  
OF PITTSBURGH, PA.

IN May, 1916, a patient, M. F., was referred to me by Doctor S. Her chief complaint was inability to close her mouth so that the teeth would come together. It seemed that the entire inferior maxilla was swung toward the right side so that the line of the teeth of the lower jaw was at least one-half inch from the line of the teeth of the upper jaw.

The inability to approximate the teeth reacted disastrously to the patient, for she was unable to chew and masticate ordinary food, and, as a consequence, she lost her appetite and was growing very thin. The present lesion has been present for the past eight months, when it resulted from a difficult effort at mastication. At first the jaw locked, but by persistent effort she was able to release it. This happened several times until the locking in the position above described became permanent and could not be released.

A study of the joint convinced me that the locking was due to a separation of the left interarticular cartilage with a forcing back of the cartilage into the temporomaxillary articulating cavity.

A search of the literature did not disclose any description of an operation for the correction of such a deformity. Accordingly, I devised the following operation:

1. An incision along the auricle and down to the pinna is made. If possible it is made in a skin crease.
2. The skin and immediate subjacent tissue are dissected back towards the face (Fig. 1). Care must be observed not to injure the superficial branches of the temporal—i.e., the posterior and anterior branches. These in many cases are given off immediately above the zygomatic process.
3. If the branches of the temporal artery are given off at a higher level than the malar, a transverse incision is made along the zygomatic process, beginning about 1 cm. anterior to the auricle. Before making this transverse incision the temporal artery should be definitely located by palpation. If the anterior branches of the temporal come off before the malar, an incision parallel to and posterior to them as shown in the cut (Fig. 2) may be made.
4. If the transverse incision has been made the next step is to define the anterior margin of the parotid. Along its anterior edge a perpendicular incision is carried down for a little over 1 cm. If the incision is carried farther the duct of Stenson may be injured, as it crosses the face at this point. The parotid is now dissected downward. The posterior margin of the masseter is now exposed. It is drawn forward. Hæmostasis is now made perfect. If the second incision has been a perpendicular one the third incision (Fig. 3) is transverse slightly above the line of articulation. The





FIG. 1.—Indicates the approximate length and location of the incision:



FIG. 1a.—Shows the normal anatomical relationships (from the Edinburgh Stereoscopic Anatomy). 1, zygoma; 2, condyle of mandible; 3, deep head of the masseter; 4, superficial head of the masseter; 5, sternomastoid muscle; 6, digastric muscle; 7, common facial vein; 8, internal jugular vein; 9, spinal accessory nerve and accompanying artery; 10, post-auricular branch of facial nerve; 11, facial nerve; 12, external carotid artery; 13, superficial temporal artery and auriculotemporal nerve; 14, facial vein.

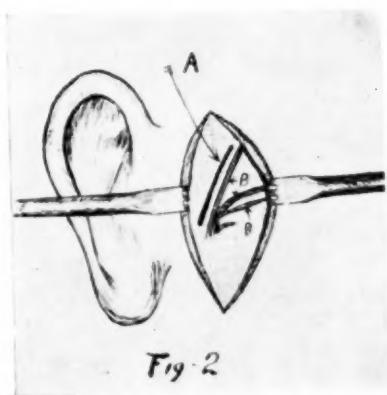


FIG. 2.—Indicates the type of incision through the fascia when the temporal vessels are given off below the zygoma. A, line of incision; B, B, vessels.

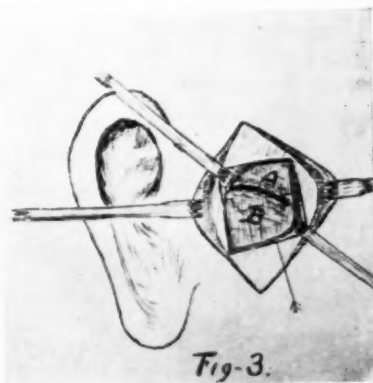


FIG. 3.—The fascial flaps are reflected and the line of incision into the temporocartilage cavity is indicated. A, the fascia over the malar; B, the fascia over the cartilage and joint.

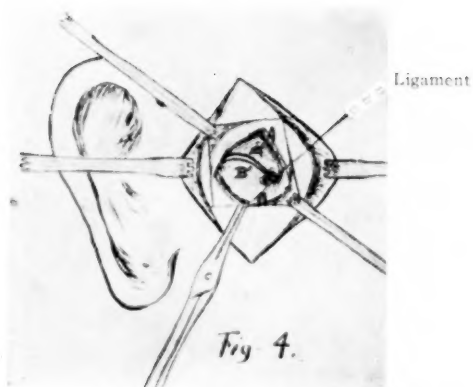


FIG. 4.—The deep fascia is now reflected as shown at *A* and at *B*, where it is grasped by a forceps. *A'* is the periosteum of the temporal bone and *B'* is the fascial covering of the cartilage and the condyle of the inferior maxilla. This seems to act as a separate capsule for the joint between the cartilage and the articulating surface of the inferior maxilla.

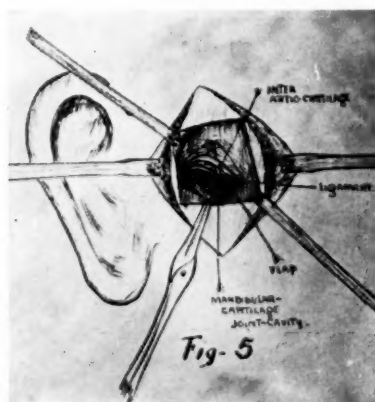


FIG. 5.—The two joint cavities are opened. The cartilage lies between them. The ligament at the anterior extremities of the cartilage where it fuses with the fascial capsule is clearly defined. *A*, the articulating surface of the temporal; *B*, the condyle of the inferior maxilla.

## LOOSE CARTILAGE IN MAXILLARY JOINT

joint cavity may accidentally be perforated. This is indicated by a discharge of synovial fluid which may be considerable if the joint is in a state of chronic inflammation.

5. The patient's mouth is now opened and the condyloid process is thrown forward, and is felt as a prominence below the zygomatic process and beneath the temporomandibular ligament.

6. The capsular ligament is incised transversely close to the margin of the articular cavity, and the cavity of the joint is opened (Fig. 4). That is the cavity between the cartilage and the articulating surface of the temporomalar bone.

7. The forceps (blunt pointed) are now introduced into the joint cavity to determine if it is entirely free.

8. If the cartilage has been torn free at its anterior end, it is found as in the present instance back in the joint cavity. The anterior edge of the cartilage is now caught and it is drawn forward and is sutured to the periosteal margin of the articular cavity.

9. If the post ligament, *i.e.*, the ligament uniting the posterior end of the interarticular cartilage and the articular cavity, is torn it is sutured to its respective margin by silk sutures, care being taken that the silk does not enter the joint cavity. Normally the cartilage is more closely connected to the condyle of the inferior maxilla than it is to the capsule. It seems to move with the inferior maxilla and to be the buffer between it and the articulating surface of the joint, so that if the cartilage is still attached to the inferior maxilla two cavities are present, the first, which is already entered, as soon as the capsule is incised (Fig. 4), and the second, which is entered by making an incision directly on the surface of the condyle. This opens directly the cavity between the cartilage and the articulating surface of the inferior maxilla. The surface of the condyle may now be examined.

Having the patient open and close his mouth will indicate the different anatomical landmarks. It should be remembered that when the jaw is closed a cavity exists between the head of the inferior maxilla and the articulating surface of the temporal.

10. After the interarticular cartilage has been sutured in place the capsule is closed by a catgut suture, as are also the fascial incisions. The skin is closed either by a catgut suture (subcutaneous) or by horse-hair.

The above operation was performed on our patient and she made an uneventful recovery. She left the hospital in eight days. She was cautioned not to open her mouth to an excessive degree. The teeth were in a perfect alignment and chewing was again normal. The patient rapidly gained in weight and in eighteen months was in perfect health. She now (December, 1917) complains of some cracking in the right joint. The left joint gives her no trouble. The scar is not noticeable.

## THE PREVENTION OF PERMANENT BRONCHIAL FISTULA FOLLOWING LUNG RESECTION \*

A CLINICAL NOTE

By HOWARD LILIENTHAL, M.D.  
OF NEW YORK

THE possibility of permanent bronchial fistula following lung resection has probably acted as a deterrent to surgeons contemplating this operation. A number of writers have suggested technical points in the treatment of the stump with a view to obviating this condition. It has been advised that after isolation and ligation of the vessels the bronchus be crushed, ligated and turned in by suture, even covering the stump by stitching lung tissue to it and over it with the double purpose of sealing and also of preventing the retraction of the bronchus into the mediastinum. In dealing with normal lung shortly after the infliction of a wound, or in the resection of tumor-bearing lung when there is no inflammatory infiltration of the hilum, these forms of technic are feasible, advisable and perhaps necessary. In resecting a chronically inflamed and densely thickened lobe, however, such niceties of dissection are out of the question. Also, firm adhesions prevent retraction of the bronchus. The danger of immediately fatal hemorrhage from large vessels firmly imbedded in the tough, almost cartilaginous stump is hardly to be avoided unless we revert to the mass ligature principle, in which, after crushing the pedicle, a chain of heavy chromic catgut transfixes every part, bronchus and vascular supply alike. Here, however, temporary leakage of air from the bronchus is almost certain to occur when some days after the operation the stump is cast off.

In the writer's earlier experiences it was feared in each case that the opening might not close. This dread seemed justified because of the bronchial fistulæ which so often followed the drainage of lung abscesses in the bottom of which there was an opening into even a small bronchial branch.

In studying the reasons for the spontaneous closure of the temporary fistula following a lobe resection it was noted that the bronchial opening was far from the thoracic wall and that the cavity which the lobe had occupied became obliterated by the approach of the surrounding soft parts to each other and the further filling in of the hollow by granulation tissue. Gradually less and less air escaped through the long, soft-walled granulating sinus until the fistula closed, then reopened once or twice and finally healed soundly. In later cases the same course was noted in sharp contrast to the permanent fistulæ following the incision of abscesses which were in contact with the chest wall where the open bronchus was close to the surface of the body. It was recognized that the farther from the chest wall the

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\* Read before the New York Surgical Society, January 23, 1918.



## PREVENTION OF BRONCHIAL FISTULA

bronchial opening was situated the more likely it was to heal. Then, a few months ago, I resected the left upper lobe in the case of a young woman who had a chronic bronchiectatic multilocular abscess following tonsillectomy. There had been hæmoptysis, fever and profuse fetid expectoration. On July 13, 1917, lobe resection was made through a long sixth interspace incision with section of the seventh, sixth, fifth, and fourth ribs posteriorly after enlarging the wound upward from its posterior extremity. In addition to the drainage in the upper back by resecting part of two ribs a small opening was made in the posterior axillary line between the ninth and tenth ribs and a tube was inserted. The upper wound closed first, but a tube was deliberately kept in the lower opening until the upper wound was soundly healed. The large bronchial fistula was at the bottom, or, geometrically speaking, at the top of a sinus about seven inches long. It finally closed after slow but uninterrupted progress and the patient is well.<sup>1</sup>

During the post-operative period when resection has been done for abscess or chronic bronchiectasis, I am not sure that the temporary fistula is an evil. Indeed, it seems to me that the opening forms a vent for secretions which might otherwise make trouble by forming a pool at the blind end of the ligated bronchus.

Out of six cases, in one—the first—there was no fistula. All the others had fistulæ. All closed excepting one in which the entire right lung is absent. The middle and lower lobes extirpated for progressive suppurative disease fifteen months after tonsillectomy, the upper lobe shrivelling completely, probably because its deformed and adherent pedicle was caught in the ligatures which surrounded the pedicle of the two other lobes. This case is to be recorded later. The patient is working as secretary in a hospital and is in good health, but there is still a large opening in the chest with open bronchus, and another operation may become necessary.

### CONCLUSIONS

1. After lobe resection for chronic inflammation a temporary bronchial fistula may be expected.
2. The fistula will probably close spontaneously.
3. It appears that as a general principle we may assume that other things being equal a bronchial fistula is apt to close in direct proportion to its distance from the body surface.

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<sup>1</sup> Case to be reported in full later.

## THE EFFECT OF SPLENECTOMY ON THE NORMAL INDIVIDUAL AND IN CERTAIN PATHOLOGICAL CONDITIONS\*

BY JAMES MORLEY HITZROT, M.D.  
OF NEW YORK

In considering the effect of splenectomy upon the human, three problems present themselves:

First, the effect of splenectomy upon the normal animal. This field has been covered by many observers. The experimental studies of splenectomized dogs, especially by Pearce, of Philadelphia, and his collaborators, are extremely valuable additions to this phase of the question; and the study of the result of splenectomy for traumatism to the normal spleen has given a large amount of material for a study of the splenectomized normal human subject.

Second, the effect of splenectomy in those pathological conditions in which splenomegaly existed, and in which this enlargement of the spleen might be considered as a principal result of the disease in question. Later on, a classification of such pathological conditions will be given.

Here one finds a vast mass of data, pathological and clinical, undigested and little understood. The results of splenectomy from the surgical standpoint have proven the empirical value of this procedure and have shown that splenectomy is neither a difficult nor a dangerous operation in chosen cases.

When cases with splenomegaly and constitutional manifestations well known to the clinician present themselves, it scarcely seems necessary to urge that the surgeon be called in when splenectomy is a relatively easy task. Watchful waiting usually results in perisplenic adhesions and in other visceral changes which thrust upon the surgeon more difficulties than are ordinarily justifiable, and convert a simple surgical procedure into a very complex and dangerous one, and, what is perhaps more serious, lessens the probability of a complete recovery.

The pathological material obtained by operation has, so far, given very little light upon the subject. The lesion, or lesions, in the spleen are identical for given clinical types of the disease, but inasmuch as these lesions are the result of an unknown process, they throw little light upon the causative factors, and there is little except speculative evidence to account for the diseases in question.

Third, the effect of splenectomy in certain pathological blood states in which splenomegaly was not necessarily a factor, but in which the empirical practice of splenectomy has shown by its results that the spleen is, to a certain extent, a factor in the disease.

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\* Read before the New York Surgical Society, November 14, 1917.

## THE EFFECT OF SPLENECTOMY

This group of diseases is even more interesting in that it carries one into so many fields for investigation.

There is very little that I can add to this confusing mass of chaotic information. My paper will endeavor to summarize what is known about the anatomy, the physiology, and the clinical features of splenic disease, with special reference to the effect of splenectomy both in the normal and in the pathological animals as gained by observations in seventeen cases of splenectomy (16 personal cases; 1 case reported by Conner and Downes).

Cause for splenectomy	No. of cases	Recoveries	Deaths
Traumatic rupture .....	5	4	1
Cyst (parasitic) .....	1	1	..
Splenic anæmia .....	3	3	..
Hematogenous jaundice .....	2	2	..
Splenomegaly with anæmia .....	1	1	..
Von Jaksch anæmia .....	1	1	..
Pernicious anæmia .....	2	2	..
Splenomyelogenous leukæmia .....	1	..	1
	—	—	—
	16	14	2

Of all the organs of the body, less is known about the spleen than perhaps any other organ, although the spleen is found practically throughout the animal kingdom. The anatomical relationships and the histology of the normal spleen are sufficiently known to require no mention in this paper.

The weight of the normal spleen is 195 grammes (Sappey).

The blood supply of the spleen is derived from the cœliac axis, as is that of the stomach, pancreas, and liver, showing an association of function, and a correlated vascular development.

The nerve supply of the spleen is derived from the splanchnic sympathetic which would indicate that in its ontogeny the spleen develops before the cerebrospinal system with which it has no connection. The spleen is rich in motor nerve fibres, which when stimulated cause it to contract. According to Schaefer, these fibres are found in the splanchnic nerves which also contain nerve fibres whose stimulation produces a dilation of the spleen. Of the physiological function of the spleen little definite is known (Howell).

Expansion and contraction of the spleen occur during digestion and these movements are synchronous with the digestive periods. The changes in the expansion reach their maximum about the fifth hour of the digestive process, and then gradually subside. In addition, there is a rhythmical contraction and expansion of the spleen in dogs and cats at intervals of one minute which, Roy considers, act to keep up a circulation in the spleen independent of the general arterial blood-pressure.

The remainder of the physiological properties are based upon theories founded upon conditions discoverable at various times in the spleen.

*Theories of the Function of the Spleen.*—1. That it is a blood-forming organ participating in the formation of the red blood-cells.

During the fetal life, and a short time after birth, the spleen produces red blood-

cells, but according to Howell there is no reliable evidence that it does this in adult life. Morris, in estimations of the red blood-cells in the splenic artery and vein, found an increase in the number of red blood-cells in the blood in the vein over that in the artery and in the peripheral circulation. In addition there is also an increased amount of hæmatin and an increased number of leucocytes in the splenic vein (Mayo).

There is evidence (Howell) that the spleen may participate in the preparation of new hæmoglobin, or in the preservation of the iron set free by the destruction of the effete red cells. According to Asher and Grossenbacher, the daily excretion of iron is greater in splenectomized dogs than in the normal dog and occurs during feeding and fasting. It may be found after the tenth week, but is usually compensated for by other organs after the fourth or fifth week.

The iron excretion *per diem* is given by them as 11 mgms. for the normal dog, and 18 to 29 mgms. in the splenectomized animals. Bayer has confirmed these results in splenectomized humans.

2. That the spleen is an organ for the destruction of the red blood-cell which has lost its vitality. This theory is based upon the microscopical evidence of the ingestion and destruction of the red blood-cell by amœboid cells in the spleen. This destruction is especially marked in certain of the acute fevers with splenic enlargement, and the histological picture is quite characteristic (for example, the Rindfleisch cells in typhoid). Pearce and his collaborators have found this destruction in normal animals after the injection of an hæmolytic serum. In the splenectomized animals the red blood-cell destruction took place in the visceral lymph-glands and in the liver, and similar cells of endotheloid shape were present in these organs.

3. That the spleen takes part in the formation of uric acid. Jones and Austrian state that the spleen contains certain enzymes (adenase, guianase, and xanthin oxydase) which convert the split products of the nucleins into uric acid.

4. That the spleen increases the consumption of, and facilitates the utilization of, food.

Richet splenectomized nine dogs, and, by careful comparison to nine control animals, was led to believe that the splenectomized dogs ate more and fattened less than the control animals. He gives tables to prove his conclusions and from them concludes that the spleen plays an important part in the digestion, assimilation, and consumption of food.

Schiff and Herzen (quoted by Howell) believe that the spleen produces an enzyme which is carried by the blood to the pancreas where it converts the trypsinogen into trypsin and hence has an effect upon the protein metabolism. This conversion, according to Howell, takes place in the duodenum, and is due to the enterokinase formed in that part of the intestinal canal.

Mendel and Gibson, from observations on the nitrogenous metabolism in man after the removal of the spleen, state that there are no detectable alterations of metabolism as a result of splenectomy.

My observations confirm those of Mendel and Gibson, and in the human, at least, refute the statement of Richet that the gain in weight and the resumption and maintenance of the weight are slower in the splenectomized than in the normal individual. A growing boy and an adult carefully observed have shown no detectable changes in those functions which deal with the resumption and maintenance of weight, and no observable changes in the normal nitrogenous metabolism, as determined by urine nitrogen estimations.

5. That there is a correlation in function between the liver and the spleen.

Pugliese (Milan) has investigated the correlation said to exist between the liver and the spleen. He investigated the secretion of the bile in the same animal before and after splenectomy and found that the volume of the bile, if anything, was increased, but that the output of the iron in the bile was markedly diminished by splenectomy. This, he considered, may be explained by the diminution of the iron

## THE EFFECT OF SPLENECTOMY

content in the liver in individuals losing the increased amount of iron in the faeces described by Asher and his pupils (*loc. cit.*).

Pugliese, furthermore, demonstrated a diminished iron content in the blood, with a decrease in the haemoglobin and in the number of the red blood-cells.

*The Effect of Splenectomy in the Normal Animal.*—In studying the effects of the removal of an organ concerning whose physiological functions so little is known, many phenomena occur which do not permit of any definite explanation, and which only partly reveal some of the phases of splenic activity due to the compensatory mechanism which brings the splenectomized animal back to a normal state.

The effect of splenectomy upon the normal individual has not only been studied in numerous animal experiments, but has also been carefully observed in an increasing number of splenectomies performed for traumatic injuries, displaced spleens, for cysts of the spleen, in which the individual had a normally functioning spleen before its removal.

It is furthermore necessary, in studying the effects of splenectomy, to eliminate such cases as have coexisting complications which are not referable to the spleen itself, as, for example, coincident injury to other viscera, injury to the pancreas during the removal of the spleen, and the conditions resulting from thrombosis of the various tributaries of the splenic vein, and the extension of the thrombus into other radicles of the portal system or of the portal vein itself.

In addition to the above precautions, in the splenectomized humans, it is also essential to eliminate from the results of splenectomy such cases as show a lesion of the spleen plus some other blood or bone marrow disease, if one is to determine the real effect of splenectomy. This latter group should receive separate consideration, and will be discussed elsewhere.

In general, the results of splenectomy in the normal are:

1. A change in the blood picture which persists for a varying period, but gradually returns to normal.
2. A change in the resistance of the red blood-cells to hæmolysis.
3. An increased output of iron in the faeces which lasts for from four to ten weeks.
4. An increase in the total fat and cholesterin in the blood of splenectomized dogs, which gradually decreased and returned to normal (Eppinger).
5. The blood shows a transient decrease in the antitryptic and bactericidal properties of the serum which rapidly returns to the normal. The agglutinins and opsonins remain unaltered (Bucalossi).

The other mentioned results of splenectomy, such as swelling of the peripheral lymph-glands, hyperplasia of the marrow of the long bones with pain in these bones, and the increase in size of the thyroid, have not received any confirmation in the experience of recent writers on the subject.

The absence of digestion leucocytosis in a case of Moynihan's, recorded by Harrison, was not confirmed in the investigations made by me in four personal cases of splenectomy on normal individuals.



The changes in the blood picture which result from splenectomy have recently been extensively studied by Pearce, of Philadelphia, and his collaborators, and are reported by Musser and Krumbhaar from observations on splenectomized dogs which were under observation from eight to ten months after splenectomy. They state in their summary that there is a gradual progressive anaemia which comes on promptly after the removal of the spleen, and reaches its maximum about the thirtieth to the forty-fifth day, and then gradually begins to return to the normal, which is reached about the third to fourth month, but the haemoglobin continues to increase in amount as late as the tenth month.

As a rule, they found that the decrease in the haemoglobin content occurred a little sooner and is more marked than the fall of the red blood-cells; and that the improvement takes place more rapidly in the red cell count than in the blood estimation. The above changes take place gradually.

The white cell count is quite characteristic for all the animals. There is an initial leucocytosis of from 26,000 to 38,000 on the day after the operation, with a rapid fall to 20,000 and then a gradual fall to normal at about the fourth month. The increase in the white blood-cells is chiefly polymorphonuclear in character. There was a transient eosinophilia which in one of the dogs persisted for 113 days and reached as high as from 10 to 32 per cent. in the differential count.

In none of these observations was there any marked increase in the lymphocytes, which averaged from 18 to 26 per cent.

Schultz made daily counts in a man splenectomized for traumatic rupture of the spleen. He found the red cells remained below 4,000,000 for one and a half months, but after the fourth month had risen to 5,200,000. The haemoglobin remained at 90 per cent. for a few days, and then fell rapidly to 70 per cent. and was 80 per cent. after forty-seven days; but at the end of four months was only 81 per cent.

There was a hyperleucocytosis which at the end of forty-seven days gave 10,000, and at four months 9300. The chief increase lay in the polynuclear cells. An eosinophilia of from 5 to 8 per cent. persisted for seventeen days, and then became normal.

My own observations of the blood pictures following splenectomy in the normal human were made upon six cases, four cases of traumatic rupture, one case of spontaneous rupture of the spleen in typhoid (reported by Conner and Downes, to whom I am indebted for the blood counts up to thirty-four days after splenectomy) and one case of echinococcus disease of the spleen. In all of these the individuals had normally functioning spleens up to the time of the splenectomy.

The six cases are charted graphically to show the blood pictures up to one year after the operation (Charts I-V—Chart of Case III is practically identical to that of Case VI, and the chart of the latter is omitted for that reason).

In the four traumatic ruptures there was a drop in the red cell count

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and in the hæmoglobin which persisted for nearly four months in all except one case in which both became approximately normal at one month.

In the spontaneous rupture, this drop in the red cell count and in the

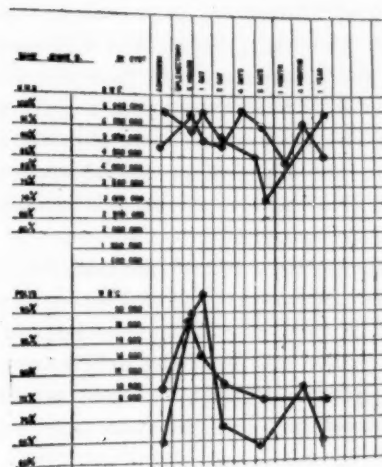


CHART I.—Echinococcus cyst of spleen. New York Hospital. Woman aged twenty-seven; duration unknown; symptoms of pain in left side for nine months. Splenectomy May 21, 1914.

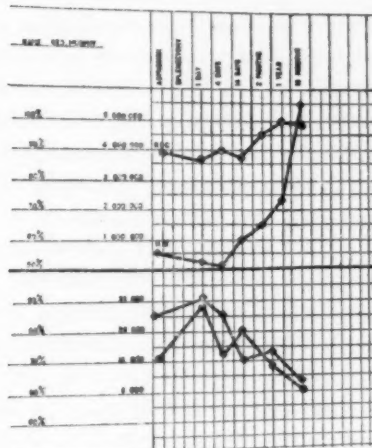


CHART II.—Traumatic rupture of spleen. New York Hospital. Boy aged fourteen. Fall on left side against curb. Splenectomy one hour and fifteen minutes after injury.

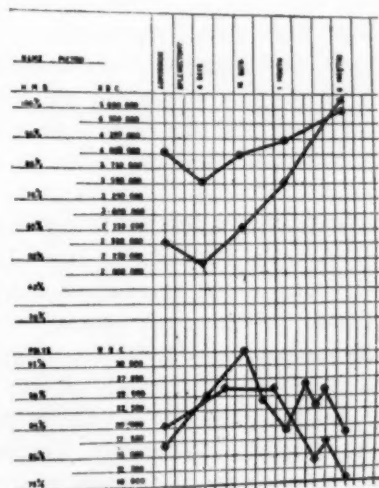


CHART III.—Traumatic rupture of spleen. New York Hospital. Boy aged nine. Struck on left side by auto mudguard. Splenectomy one hour and thirty minutes after injury.

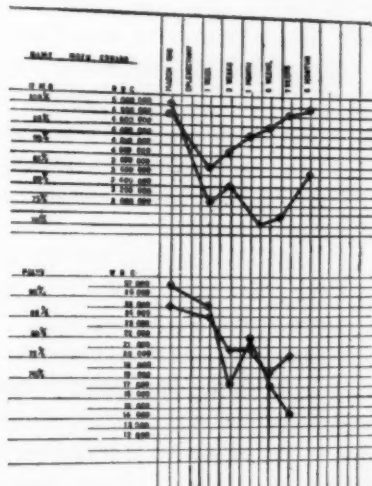


CHART IV.—Traumatic rupture of spleen (injury of spleen due to laceration by fractured rib). New York Hospital. Man aged forty-nine. Fall down elevator shaft. Splenectomy three hours after injury. Sharp edge of broken rib opposite vent in spleen.

hæmoglobin was quite marked and lasted two months for the red cells and four months for the hæmoglobin.

The parasitic cyst showed a curious variation in the red cell count in

that there was a polycythæmia which lasted for the first four days, then dropped below normal but to a very much less noticeable degree than in the other cases. The hæmoglobin fell steadily for one month and gradually rose to normal at one year: That is in the normal human after splenectomy, there is a gradually increasing anæmia which in this series lasted about four months and was most marked in the cases with the greatest loss of blood. The hæmoglobin remained below normal for a longer period than did the red cells and in the majority of the cases it was almost a year before it reached the normal. That is, the findings are quite comparable with those of Pearce and his collaborators for dogs. One case (V. S.) showed a primary transient polycythæmia, and in this case there was no hemorrhage other than that which occurs in any ordinary laparotomy.

The white cell count showed an initial abrupt rise in the white cells which reached 68,000 in the case with the most marked hemorrhage and was lowest in the case without hemorrhage, 19,800. The chief change was in the polynuclear count, and this was most marked in the case with the least hemorrhage. This hyperleucocytosis lasted for from sixteen days to one month, the chief change taking place in the first week and the fall from there on being more gradual.

There was a relative eosinophilia of 4 to 5 per cent. in the traumatic cases and in the echinococcus cyst, which persisted for approximately two months.

That is, in the human there is an initial leucocytosis which is polymorphonuclear in character and which lasts for approximately one month. There was a greater variation here than was observed by Pearce *et al.* in the animals, but in general the conditions were approximately parallel.

It was also noticed, as pointed out by Conner and Downes, that the rapid rise in the leucocyte count became evident before any change in the red cells or the hæmoglobin, as a result of hemorrhage, and this feature should be given more diagnostic emphasis, especially in the traumatic cases, as a sign of hemorrhage.

The two youngest of the traumatic cases showed a few nucleated red cells during the first ten days, as did the spontaneous rupture, but this had disappeared by the sixteenth day. There were also a number of abnormally large cells in these cases during the same period.

A change in the resistance of the red blood-cell occurs after splenectomy.

An increased resistance of the red blood-cell of the splenectomized individual to the action of the hæmolytic agents has been noted by a number of investigators, Bottazzi, Banti, Vast, Pugliese, Luzzatti, Joannovics, Pearce and his collaborators in dogs, Gabbi in the guinea-pig, Domenicci in the rabbit.

The hæmolytic agent usually used was toluylenediamine. Pugliese and Luzzatti used pyrodine; Banti, acetyphenylhydrazine; Joannovics, Pearce and his collaborators, specific hæmolytic serum, and Pearce *et al.*, sodium oleate.

The experimental work done to determine this resistance on the part

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of the red blood-cells has been extensive. In brief, two methods have been used, the injection of a hæmolytic agent and the estimation of the resistance of the red blood-cell to the action of this agent by the comparative production of hæmoglobinuria and jaundice in the splenectomized and in the normal animal. By this method it was found that an increased amount of the hæmolytic agent was necessary to produce hæmoglobinuria and jaundice in the splenectomized animal.

Second, the estimation of the hæmolytic action of hypotonic salt solution on the red blood-cell (fragility test). Charlier and Charlet described an increased resistance to hæmolysis following splenectomy as determined by testing the fragility of the cells of oxalated blood in varying strengths of salt solution.

Pearce and his collaborators in an elaborate number of experiments have shown that in splenectomized dogs after a period of nine days has elapsed, the increase in the resistance of the red blood-cell corresponded to a difference of 0.1 per cent. in the salt solution used, that this resistance did not increase and was present up to seven and a half months after splenectomy.

They furthermore demonstrated by their experiments that the increased resistance of the red blood-cell to hypotonic salt solution and to hæmolytic agents was due, not to an increased hæmolytic power of the animal's serum, or to a diminished complementary value of the serum, but that the power of resistance was inherent in the red cells themselves. Their experiments produce one very interesting paradox, namely:

"In splenectomized dogs anæmia caused by hæmolytic poisons (hæmolytic immune serum and sodium oleate) and by hemorrhage is of a severer grade, runs a longer course, and is accompanied by a less rapid regeneration of blood in the splenectomized than in the normal dog. Also in a splenectomized dog, especially after the use of hæmolytic serum, the leucocytosis is greater than in the normal dog.

"The splenectomized animal almost uniformly exhibits an increased resistance of red blood-corpuscles to hypotonic salt solution, but after the administration of hæmolytic poisons, and especially hæmolytic serum, this increased resistance disappears, and decreased resistance persists for a long period of time. The same change occurs in the normal dog, but in the latter the return to the previous degree of resistance is more rapid than in the splenectomized animal."

In their discussion they state that "this seems, at first glance, to contradict the earlier work in which it is shown that red blood-corpuscles of splenectomized animals were more resistant to hæmolytic agents than in the normal dog, and that in such, hæmolytic jaundice is not so readily produced. On this basis one could hardly expect a hæmolytic poison to cause in splenectomized animals a more severe anæmia than occurs under similar circumstances in the normal animal.

"The present investigation, however, shows this to be the case, and, moreover, that hæmolytic poisons change the more resistant cell of the splenectomized animal to less resistant cells, and this diminished resistance persists longer than in the normal dog. It is evident, therefore, that the immediate destruction of the red blood-corpuscles by hæmolytic agents as shown by hæmoglobinuria and the result of the blood examination, is not the only factor in the production of anæmia, but that in the splenectomized animal some added factor plays an important part. The hæmolytic agent inaugurates an acute anæmia, but the absence of the spleen is an



important secondary factor in increasing the severity of the anæmia, and in either prolonging its course or delaying the process of repair.

"Therefore, the phenomena associated with the absence of the spleen, *i.e.*, the increased resistance of the red blood-cells and the decreased tendency to jaundice after the administration of the hæmolytic poisons, are correlated and intimately associated with the anæmia of splenectomy; but that the anæmia itself is dependent upon some factor as yet unknown which operates in the absence of the spleen. This unknown factor would also operate in the anæmia produced in such animals by hæmolytic serum and, more especially, as the hæmolytic anæmia is characterized by a decreased resistance of the red blood-cells. As the factor dependent upon the absence of the spleen does not operate in the normal animal the latter recovers quickly. It seems possible, therefore, thus to explain the more severe and more prolonged anæmia in such animals even though they may have more resistant corpuscles."

Fragility tests were made upon three of the cases in this series (two traumatic cases, one echinococcus case) in the earlier stages and the red cells found to be more resistant to the action of the hypotonic salt solution than the normal control. This increased resistance began on the eighth, tenth and eleventh days and was present six, seven, and nine months. Two other cases showed an increased resistance on the sixth and eighth months respectively, the only observations made in these cases.

That is, in the human there was a comparable increase in the resistance to hæmolysis of the red cell by hypotonic salt solution similar to that found by Pearce *et al.* in the dog, and that it lasted for approximately the same period.

An increased output of iron in the fæces:

Asher and his pupils have contributed a full literature upon this subject for splenectomized dogs (*v. supra*).

Bayer from Garre's clinic reports the investigation of a case of traumatic rupture of the spleen in which this increase in the output of iron was present as compared to a control patient. He estimated the iron excretion in both patients beginning on the fourteenth day after the splenectomy when they were placed upon a diet rich in iron and one very nearly iron free, and reports the following difference:

Splenectomized	Control
Iron-rich diet, 22 mg. per day.....	16 mg.
Iron-poor diet, 17.8 mg. per day.....	14.7 mg.

Three months after splenectomy he found:

Iron-rich diet, .512 .....	.505
Iron-poor diet, .234 .....	.183

From this investigation up to the third month after splenectomy he concludes that the splenectomized individual excretes a larger quantity of iron than the normal, and especially so during the iron free period.

An attempt was made in one case to estimate this factor, but the great variation in the iron content of the foods tested gave so great a source of



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error that no satisfactory result was obtained. Any method for such estimation would, in view of the very small quantitative differences in the iron excreted, require a synthetic diet in which the ingested iron was absolutely the same in each individual.

A total increase in the fat and cholesterin in the blood:

Eppinger estimated the total fat in 1000 c.c. of blood in dogs which he subsequently splenectomized, and found that there was a definite increase in the amount of fat and cholesterin up to two months after splenectomy, and that it was at the maximum about two weeks after splenectomy.

Bloor, in his recent investigations on the fat content of the blood in normal dogs, found it to be constant both for the individual and for the species. The average variation was 7 per cent., the greatest variation 14 per cent. Bloor believes that there is sufficient reason to expect a similar fat value in humans.

The matter is, as yet, too indefinite to determine its relationship to the splenectomized individual. When splenectomy is contemplated a careful pre-operative estimation of the fat content of the blood followed by a similar investigation under similar dietetic conditions after operation might give some interesting data. No investigations as to this factor were made in this series.

Among the numerous experimental studies upon the function of the spleen and the effect of its removal are the observations by Lewis and Margot that the removal of the spleen from albino mice greatly increased the resistance of the mice towards infection by the bacillus tuberculosis (bovine type). They do not offer any explanation for this resistance to infection.

Blach and Weltmann, in experiments upon the growth of rat sarcomata, state that splenic tissue mixed with the rat sarcoma and injected into an animal, exerted a marked inhibitory influence upon the growth of the tumor tissue. They offer as two explanations of this action (1) that the splenic tissue may increase the natural protective substances of the body, or (2) it may exert a destructive influence upon the tumor cells by reason of some contained ferments.

Vital staining of the red cell by the method of Widal showed an increase in the number of these cells which was greatest in the cases with the most marked hemorrhage and greatest in number in the case with the most nucleated reds. This increase in the vital staining red cells lasted for an average of twelve days, when it began to decrease and regained the normal at an average of the third week.

*The Effect of Splenectomy in Certain Pathological Conditions.*—Splenomegaly occurs under a number of conditions: Some of the types of splenic enlargement such as:

1. Splenomegaly in infectious diseases (typhoid, malaria, ulcerative endocarditis, tuberculosis, etc.).
2. Splenomegaly due to chronic venous congestion as a result of cardiac or pulmonary disease.

3. Splenomegaly in amyloid disease.

4. Splenomegaly in syphilis are rarely surgical spleens, with the exception of the malarial spleen when it becomes chronically enlarged, and the syphilitic splenomegaly in which the lesion seems to be harbored in rare instances (Hartwell).

Splenomegaly in cirrhosis of the liver:

(a) Biliary cirrhosis (Hanot type) including the metasplenomegalic form of the French writers in which the enlargement of the spleen precedes that of the liver and is relatively greater.

(b) Portal cirrhosis—alcoholic and other forms.

(c) The luetic cirrhosis.

(d) The congenital obliteration of the bile-ducts with cirrhosis and splenomegaly.

In all of the above, the coincident disease of the liver renders it unlikely that any operation directed toward the spleen would offer any benefit. (Mayo in a paper before the New York Academy of Medicine stated that the spleen had been removed four times for biliary cirrhosis with benefit. He also considered splenectomy as of value in portal cirrhosis in young individuals without an alcoholic history.)

Splenic anæmia:

(a) Splenic anæmia of childhood (Von Jaksch's anæmia).

(b) Banti's disease (including Egyptian splenomegaly).

Splenectomy is an essential therapeutic measure in all of the above cases, and in cases properly selected the outcome is very gratifying.

In splenomegaly with acholuric jaundice, that is, the so-called hæmatogenous jaundice of the familial type, which begins in childhood, and is stated to run through families, although in the two cases in my experience the women were the only members in the family who were affected, splenectomy is an essential therapeutic measure and a cure usually results.

Pearce and his collaborators offer a very interesting explanation for the production of jaundice in these cases based upon the experimental injection of hæmoglobin into the blood and the production of acholuric jaundice. (See Pearce, Austin, Eisenbry, "The Relation of the Spleen to Blood Destruction and Regeneration and to Hemolytic Jaundice: II. The Relation of Hemoglobinemia to Hemoglobinuria and Jaundice in Normal Animals and Splenectomized Animals." *Journal Experimental Medicine*, 1912, 16, p. 374.)

"Upon these data may be based the following explanation of the mechanism by which free hæmoglobin is removed from the blood serum. Hæmoglobin is not removed by the kidney until its concentration in the blood stream reaches a certain level (0.06 Gm. free hæmoglobin per kilo body weight).

"This constitutes threshold value of the kidneys for hæmoglobin and when it is reached hæmoglobin appears in the urine. When concentration is lower, hæmoglobin ceases; at the same time the liver, and possibly other tissues, take up the hæmoglobin as soon as mere traces are present in the serum, and they continue this removal whether the renal threshold is exceeded or not. The two processes go on simultaneously, the rate of removal when the renal threshold is exceeded being for the kidneys 17 to 36 per cent. and liver and other tissues 64 to 83 per cent. of total amount intro-

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duced. The hæmoglobin removed by the liver is transformed into bile pigment. If the amount reaching the liver is small and is received slowly, the amount of bile formed is not increased above the excretory capacity of the liver, and is removed by the bile-passages without the occurrence of choluria. This is shown in our experiment in which the injections of hæmoglobin were made more slowly than 0.01 Gm. per kilo per minute. On the other hand, if the hæmoglobin is taken up by the liver rapidly and in large amounts, the bile capillaries are overtaxed and the bile cannot be rapidly removed, but is reabsorbed into the blood and choluria develops.

"If this theory is correct we have an explanation of those instances of blood destruction in man characterized by jaundice but not accompanied by hæmoglobinuria. In a slow gradual destruction of the red blood-cells the liver removes the hæmoglobin from the serum so rapidly that the concentration of the hæmoglobin in the serum does not reach the threshold value of the kidneys, and therefore the hæmoglobinuria cannot occur. The constant absorption of large amounts of hæmoglobin by liver and the increase in bile formation which results does, however, overtax the bile-passages, and jaundice occurs.

"In the same way may be explained the continuance of jaundice after the disappearance of transient hæmoglobinuria. A rapid destruction of a large amount of blood raises the concentration of hæmoglobin in the serum so quickly that the threshold value of the kidney is quickly exceeded and hæmoglobin in large amounts appears in the urine. When an amount of hæmoglobin sufficient to reduce the concentration of the serum below the threshold value of the kidney has been removed, a considerable amount of hæmoglobin may still remain in the serum, and it is the slow elimination of this through the liver that causes the choluria to continue.

"The demonstration that the absence of the spleen has no important influence in the elimination of hæmoglobin by the kidney or its transformation into bile-pigments, or on the removal of such pigments is of interest in connection with the observations made in the first paper of the series. That is, the frequent failure of the jaundice to follow the administration of the hæmolytic serum during the early periods following splenectomy. Among the possible explanations was the suggestion that the spleen is in some way concerned in the disintegration of free hæmoglobin, or in the elaboration of its derivatives. The present investigations demonstrate that such an explanation is without experimental basis, though it does not controvert the possibility of the spleen being concerned in liberating the hæmoglobin from the red blood-cells, and suggests that failure of jaundice is due to some other factor or factors. Evidence to indicate that the changes in the blood that follow splenectomy are important factors is offered in the third paper."

### Splenectomy in pernicious anæmia:

Splenectomy, so far, has proven of empirical value in certain types of this form of anæmia, although a much wider knowledge of the types to be submitted to splenectomy must be obtained before it will be possible to determine which group of these cases is essentially the one for such a surgical procedure.

The series here reported contains seven cases of splenomegaly of varying types (splenic anæmia (Banti's), 3; splenomegaly of unknown type with anæmia, 1; hæmatogenous jaundice, 2; Von Jaksch's anæmia, 1), two cases of pernicious anæmia and one case of splenomyelogenous leukæmia.

In these cases the same observations were made upon the blood picture, weight of the individual, the fragility of the red cell and the vital staining with certain exceptions which appear in the text.

Of the three cases of Banti's disease, one case was markedly improved for nine months and then, due to the increasing cirrhosis of the liver, developed ascites, and in the fourteenth month a mesenteric thrombosis from which he died. The case was a late one of its type, and at the time of the operation there was an advanced cirrhosis of the liver with numerous perihepatic adhesions. At the autopsy a well-marked collateral circulation existed between the capsule of the liver and the diaphragm, the parietal peritoneum and the omentum. The mesenteric thrombosis was only a partial one, involving about half of the small intestine, but the patient refused any further operation and died from the results of that thrombosis.

The second splenectomy for Banti's disease is now six months past the operation, and is in splendid health and without symptoms, but it is too early to state anything definite regarding the outcome of the case.

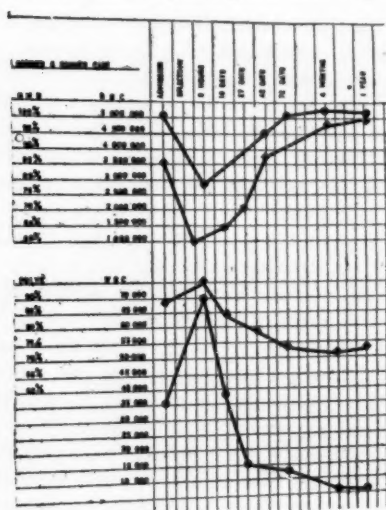


CHART V.—Conner and Downes' case of spontaneous rupture of spleen in typhoid. Splenectomy (Downes) four and one-half hours after rupture.

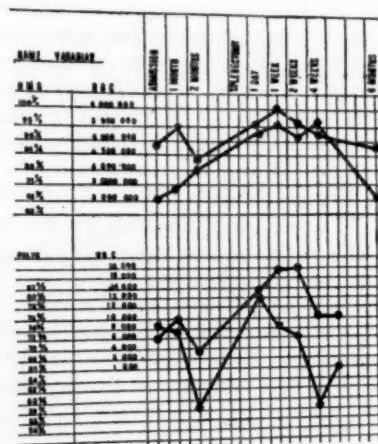


CHART VI.—Splenomegaly, Banti's type. New York Hospital. Man aged thirty; Armenian; duration sixteen years. Splenectomy December 6, 1913. Weight of spleen twenty-seven ounces. Pathological report: Banti's disease (Dr. Elser). Died nine months after operation from mesenteric thrombosis.

The third case has returned to Italy and is serving in the army and the details of this case are too brief to report at length, as the case was followed for only sixteen days.

The two cases followed sufficiently long show a definite drop in the red cell count and in the hæmoglobin beginning at the tenth and the fifth days, respectively, and in both instances this drop was more evident in the hæmoglobin than in the red cell count. The improvement was gradual in both cases and the relative curve is about the same as in the traumatic cases, although the transitions are more gradual (see Charts VI and VII).

The white cells show a definite increase both in the number of the cells and in the polymorphonuclears, although this increase is less marked than in the normal individuals and the resumption of the normal curve occurs earlier, that is, on the tenth and third days, respectively.



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Fragility tests by hypotonic salt solution made before the operation showed a beginning hæmolysis at .48, complete at .36. After the operation (twelve days) this was .46 and .44, with the complete at .28, showing a slight increase in the resistance of the red cells during this stage. Later observations were not made.

Vital staining of the red cell showed two and three cells in 500 red cells counted before operation. Only one observation was made after the operation on the fourth and fifth days, respectively, and this showed 8 and 10 vital staining cells in 500 counted. That is, there is a relatively small increase in the vital staining cells after splenectomy in Banti's disease as represented by the two cases here reported.

Both patients had improved in appearance, felt stronger and both had gained in weight since the operation—one 35 pounds at six months, the other 30 pounds at four months—and both had resumed their occupations. One case showed at nine months the changes mentioned above and the other case is still in good health.

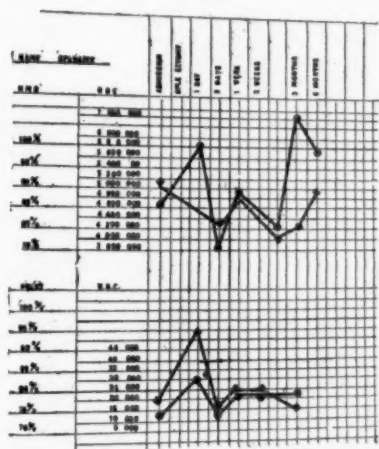


CHART VII.—Splenomegaly, Banti's type. New York Hospital. Man aged thirty; Turkish; duration five years. Splenectomy May 16, 1917. Weight of spleen 1150 grammes.

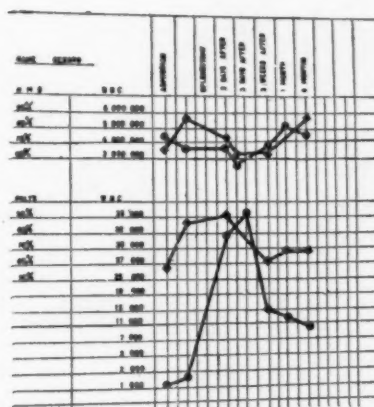


CHART VIII.—Splenomegaly—type not determined. New York Hospital. Woman aged twenty-nine; Italian; abdominal pain and pallor for four years. Splenectomy March 9, 1915. Weight of spleen 870 grammes.

The case of splenomegaly with anæmia classified separately (Case VIII, Chart VIII) was so classified because the pathologist did not consider the case as one of Banti's disease and was unable to give it any definite position among the diseases of the spleen.

There was a slight but perceptible drop in the red cells and the hæmoglobin beginning on the second day after splenectomy with a slow but gradual rise in both up to the third month. The relative decrease was approximately the same for the red cell and the hæmoglobin and the red cell curve was slower but steadier in its rise than the hæmoglobin.

The white cells showed a marked increase in number with a less definite



polymorphonuclear increase, which dropped again to the pre-operative condition on the eleventh day and was apparently normal at the three-month period.

Fragility test: Before operation hæmolysis with hypotonic salt solution began at .44 and was complete at .32. After operation nine days, twelve days and three months, hæmolysis began at .46, .48 and .48 and was not complete, although nearly so, at .26, thus showing very little change in the resistance in the red cell to hæmolysis.

Vital staining is mentioned as normal before the operation. Three days after operation, there were sixteen vital staining cells in 1000 red cells counted, an increase in the vital staining cells.

The patient has shown no change in weight since the operation. Her general health has improved, and three years after operation she reports that she is well but has a small baby and could not appear for examination.

There were two cases of hæmatogenous jaundice in this series, only one of which, the more recent one, was investigated with sufficient detail to make a satisfactory record for this report. Both cases have recovered from the symptoms which existed before the operation performed three and one-half and eight years ago.

The most marked effect shown in the blood pictures in these cases was the rapid rise in both the red blood-cells and in the hæmoglobin which began immediately after the splenectomy, as is especially well shown with Chart IX, Case IX.

In these there was not the temporary anæmia which occurred as the result of the previously analyzed cases, and this fact is worthy of notice as actually differentiating this particular disease from the other types of splenomegaly. In the case of three and one-half years' duration this improvement has been permanent.

The white cell count showed very little change, the increase in the cells being a little less than 10,000 and most marked on the third day after operation, at which time the increase in the polymorphonuclears likewise reached its highest level, 82 per cent.

Fragility tests by hypotonic salt solution before operation showed a beginning hæmolysis at .74 which was complete at .58. This remained constant until the twelfth day, when it began at .62 and was complete at .46. The resistance of the red cell increased constantly until the thirty-fifth day, when hæmolysis began at .48 and was complete at .30. Other observations have occasionally shown an upper level of .46, but the constant level was more frequently .48.

Vital staining showed six to ten cells in five hundred cells counted before operation with a rare nucleated red cell. After operation there was a definite increase in the vital staining cells which was most marked on the eighteenth day, when it was forty-six to sixty in five hundred red cells counted. For the first few days there was a definite increase in the nucleated red cells, about one cell being present to the field. This increase gradually diminished

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and at the sixth month and one year interval was three to five hundred red cells counted.

The patient rapidly improved in weight and strength. The weight before operation was 86 pounds; three months after operation it was 108 pounds.

Splenectomy was done for one case of Von Jaksch's anæmia (this case is reported in full by Stillman, *American Journal Medical Sciences*, February, 1917, vol. cliii, p. 218, Case I).

The child, a girl of nine, showed no improvement under medical treatment and steadily lost ground. Before operation (see Chart X) hæmoglobin was 23, red cells, 2,100,000. No nucleated reds were noticed and the vital cells were 145 in 500 cells counted. Hæmolysis began at .62 and was complete at .44.

Following the splenectomy (see Chart X) there was a rapid rise in the hæmoglobin and in the red cells, which has remained permanent.

The white cells showed no definite change following the splenectomy, and such changes as did occur took place in the polymorphonuclears, which

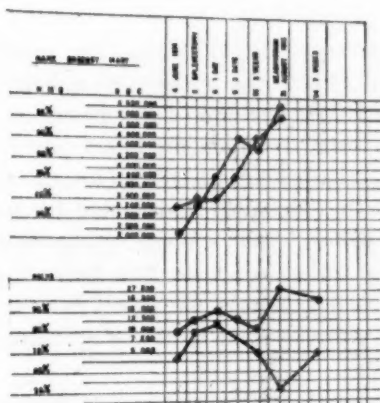


CHART IX.—Acholuric jaundice. New York Hospital. Woman aged twenty-six; recurring attacks of jaundice since childhood; no other members of family affected. Splenectomy June 5, 1915. Weight of spleen 683 grammes.

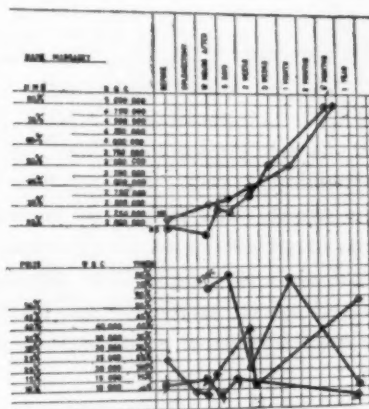


CHART X.—Von Jaksch's anemia. New York Hospital. Girl aged nine; duration seven years; enlargement of spleen and anemia. Splenectomy March 21, 1914. Weight of spleen 1420 grammes.

rose in two weeks to approximately the normal polynuclear percentage (before operation they were only 25 per cent. of the white cells).

One month after operation, hæmolysis began at .50 and was complete at .38. Nine months after operation hæmolysis began at .44 and was complete at .28, showing a marked increase in the resistance of the cell.

The most striking feature of this particular case was the shower of nucleated red cells which was noted twelve hours after the operation. At one time (five days after operation) the nucleated red cells represented 85 per cent. of the nucleated cells in the smear.

The child rapidly improved both in weight and height on exactly the same diet she had had before the operation, and in this case the effect of the

splenectomy was even more striking than that procedure in the acholuric jaundice cases.

The position of splenectomy as a therapeutic measure in pernicious anæmia has not yet been determined, because of the lack of knowledge as to the cause of the anæmias grouped under this common name. So far there have been identified the anæmias due to parasites (*Bothriocephalus latus*); the hæmolytic anæmias due to syphilis, new-growths (carcinoma), and certain intoxications (those of the puerperium for example); the chemical anæmias (potassium chlorate, phenylhydrazine, etc.); and the anæmias due to hæmatogenous jaundice. All the above belong to what may be spoken of as hæmolytic anæmias. Further than that, one may speak of the anæmias classified under the name of pernicious anæmia as (1) due to disturbance of blood formation, *i.e.*, the aplastic anæmias, and (2) the anæmias due to increased blood destruction, or hæmolytic anæmias (Addison-Biermer types).

The anæmias in which there is a disturbance of blood formation, if they can be definitely classified and recognized, cannot be benefited by splenectomy, inasmuch as the trouble does not lie in the spleen, but in the blood-forming organs.

In the other type, *i.e.*, those showing increased blood destruction, many factors as yet undetermined must be solved before the position of splenectomy as a therapeutic measure can be settled. At one end of this group one finds cases in young individuals, all under forty, in which the blood picture is somewhat atypical, in which blood destruction occurs in crises (hæmatogenous crises) with periods of remission, with a definite enlargement of the spleen in which the result of splenectomy brings about a result comparable to that seen in acholuric or hæmatogenous jaundice cases. In these the enlarged spleen seemingly has some increased action in the blood destruction and its removal is followed by definite improvement if not by an actual cure.

Between these two extremes, aplastic anæmia and the type comparable to the hæmatogenous group, is a middle group in which manifestations of inhibition of blood formation or increased blood destruction occur either separately, in conjunction or in sequence. Just when an individual with an increased blood destruction may begin to show aplasia as a result of this constant blood destruction, or whether the factor producing the hæmolysis may likewise produce an inhibition of blood formation coincident with the increased destruction, or whether the inhibition of blood formation may produce an imperfect formation of the red cell which permits of this ready destruction, are problems to be solved.

Splenectomy cannot benefit the cases with signs of marked inhibition of blood formation. In cases with marked blood destruction, in the absence of any other evidence as to the cause of this destruction and when enlargement of the spleen is present, it is a therapeutic measure worthy of further trial. In the intermediate group too many indefinite factors appear to make any general statement, but in the types with evidence of increased blood de-

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struction, if splenectomy is to be used as a therapeutic measure, it should be done before the signs of inhibition of blood formation appear. When these signs of aplasia have appeared it is much less likely that the removal of the spleen can have any effect.

In general, the evidence for splenectomy may be said to be an *anæmia* of the hæmolytic type with enlargement of the spleen, the occurrence of hæmatogenous crises or evidence of periodic increase in blood destruction and the failure to find any evidence of focal or constitutional disease to explain the cause for the *anæmia*.

Lukis believes that the presence or absence of the vital staining cell is of prognostic value, *i.e.*, in the cases of anæmia in which vital staining red cells are absent, the prognosis is bad for any therapeutic measure, and conversely when they are present or increased in number the prognosis is better. It would seem wiser from the writer's limited experience to go even further than this, *i.e.*, when the vital staining cells are absent or present only in a

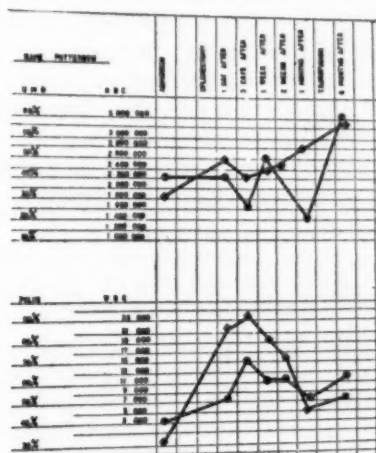


CHART XI.—Pernicious anæmia. New York Hospital. Man aged thirty-seven; duration indefinite two months' history. Splenectomy May 16, 1916.

little less than the normal ratio, splenectomy can be of little or no help. If the vital staining cells are present in an increased ratio above the normal, splenectomy must be considered and the greater this increase the more definitely does the blood present evidence of increased hæmolysis as compared to decreased blood formation.

Likewise, those cases with a ratio at or a little above normal which after splenectomy show a marked increase in the vital staining cells are much more likely to be benefited by the operation.

NOTE.—Since this article was written, Minot (*J. A. M. A.*, vol. lxi, No. 23, p. 1926) considers that the blood platelets give the best information as to the activity of the bone marrow. He furthermore states that in the anæmias at the Massachusetts General Hospital studied by Lee and himself there was a greater degree of improvement in the splenectomized and trans-

fused group than in any other group (85 per cent. of splenectomized showed some definite improvement, 45 per cent. showed marked rapid gains). Barker's paper in the same number of this journal is also worthy of perusal.

There were two cases of splenectomy for pernicious anæmia in this analysis:

The first case belongs in what has been spoken of as the intermediate group and belongs to that portion of this group in which the constantly recurring blood destruction was followed by signs of inhibition of blood formation.

Following the removal of the spleen there was little change in the blood picture. Before operation vital staining cells were present two to three in five hundred red cells counted. After operation three to five vital staining cells in five hundred cells counted. The patient was repeatedly transfused with benefit at first but without any benefit in the later stages, and died four months after the operation.

The case was not a suitable one for splenectomy because of the signs of disturbance in blood formation and the absence of any signs of increase in the size of the spleen. She came under observation when these signs were not clearly understood and after long observation outside the hospital. Transfusion and the other methods had failed and splenectomy with transfusion likewise failed. Whether she represents the type of inhibition of blood formation as a result of periodic blood destruction or not is open to question. Study of the case makes that supposition seem likely.

The second case in the series belongs in the group (see page 556) in which the essential factor was that of increased blood destruction. The history of the patient, a man of thirty-seven, was negative except for three or four attacks of jaundice ten years ago. Following this he was perfectly well until April 26, 1917, when he felt weak and dizzy. At this time he noticed that he was pale and he had to discontinue work. He was admitted to the New York Hospital, Doctor Conner's service, where a very thorough examination revealed nothing except a high degree of anæmia of the primary type without evidence of any etiological factor. During his period of investigation on the medical side he steadily grew worse, and his anæmia increased. There was a definite enlargement of the spleen. Urobilin was present in the urine, coincident with the crisis in which the anæmia increased as determined by the blood picture. On May 16, splenectomy was done, and a spleen three times the size of the normal removed.

Before operation his blood picture showed: Hæmoglobin, 32 per cent.; red cells, 1,850,000; color index, 0.89; white cells, 3850; polymorphonuclears, 63 per cent.; transitionals, 2 per cent.; large mononuclears, 5 per cent.; lymphocytes, 28 per cent.; eosinophiles, 1 per cent.; basophiles, 1 per cent.

There were nucleated red cells in small numbers and vital staining cells sixty in five hundred counted. The red cells showed some oligochromæmia, anisocytosis and poikilocytosis. Hæmolysis began at .62 and was complete at .42.



## THE EFFECT OF SPLENECTOMY

Following the operation, there was an immediate improvement in his hæmoglobin and red cell count, a rise in the leucocytes, especially in the polymorphos (see Chart XI). This improvement remained stationary for about three weeks, when he was transfused and 120 c.c. of blood given by the syringe method (Lindaman), following which his improvement was again marked. At the time of this report, six months after splenectomy, he has gained in weight, thirty-seven pounds, he feels perfectly well, and his blood picture is apparently normal.

Twelve days after operation, hæmolysis tests by hypotonic solution showed beginning hæmolysis at .48 and complete at .34. Six months after operation, hæmolysis began at .48 and .46 and was complete at .28.

The case represents the type of increased blood destruction occurring in crises and, while the period is yet too short to state so positively, can, I believe, be represented as a cure. Comparison of the chart of this case with that of Case IX, Chart IX, shows that there is a definite difference in the recuperation of the blood as compared to that in a definite case of acholuric jaundice.

## THE VALUE OF PYLORIC EXCLUSION IN THE TREATMENT OF PYLORIC AND DUODENAL ULCERS

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THE great value of gastro-enterostomy in the treatment of pyloric stenosis is an undisputed fact. If the obstruction is caused by a malignant growth, the operative result will, of course, be of temporary benefit only. If, on the other hand, the obstruction is caused by a benign ulcer of the pylorus or in the duodenum, gastro-enterostomy will effect a permanent cure. In fact, gastro-enterostomy in cases of benign pyloric obstructions gives undoubtedly the best clinical results. The benefit derived from this operation in cases of benign obstruction is much superior to the operative results following simple gastro-enterostomy in cases of non-obstructing ulcers of the pylorus or the duodenum.

The great efficiency of gastro-enterostomy in pyloric obstruction is based upon purely mechanical factors. The pylorus being completely obstructed, no food can pass into the intestines. Simple gastro-enterostomy reestablishes the connection between stomach and intestines and restores an unobstructed way for the passage of food. Gastro-enterostomy thus acts as a simple drainage operation in cases of pyloric stenosis.

It is, however, a well-established fact that the great majority of pyloric and duodenal ulcers do not cause any physical obstruction. The clinical symptoms are not caused by a narrowing of the outlet of the stomach. The food can and does pass freely from the stomach into the small intestines. In fact, a great deal of the distress which the patients complain of is caused by the passage of food over the ulcer-bearing area.

Simple gastro-enterostomy could only be considered as the ideal operation for non-obstructing ulcers of the pylorus or duodenum, if the food could be permanently and absolutely sidetracked. Such result was formerly supposed to be attained. Gastro-enterostomy was first suggested for the treatment of non-obstructing ulcers of the pylorus and duodenum as a purely sidetracking procedure. Extensive experimental work on this question has, however, proved that this hypothesis is erroneous. Yet, even at the present day, many surgeons consider gastro-enterostomy as a safe procedure to keep food material away from the ulcer-bearing area.

As far back as 1900 Kelling made very extensive studies on the passage of the food following a gastro-enterostomy. He established two intestinal fistulæ on gastro-enterostomized dogs, one in the jejunum, distal to the gastro-enterostomy, and one in the duodenum. He then injected 250 c.c. of water, colored with methylene blue, into the stomach and obtained 235 c.c.

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from the duodenal fistula and not more than 11 c.c. from the jejunal fistula. He concluded that occlusion of the pylorus offers the only guarantee for the patency of the gastro-enterostomy.

Röntgenoscopy and röntgenography offered a very good means for studying this question in animal experiments and on the human being. The literature on this subject has grown so rapidly during the last decade that it would be impossible to give a complete bibliography.

HARTMANN pointed out that the stomach consists of two parts, the cardiac part, which acts as a reservoir, and the pyloric part, which acts as a motor. In other words, the food is mixed thoroughly with the gastric juice in the cardiac part of the stomach before it slides into the pyloric part. After its arrival in the pyloric part, the food is pushed promptly into the duodenum. He concludes from a series of animal experiments that if an anastomosis is made in the pyloric antrum, the evacuation of the food takes place principally through the stoma. If, however, an anastomosis is made in the fundus, the evacuation takes place principally through the pylorus.

GUIBE's viewpoint is even more radical. "All the experiments on animals and observations on men seem to agree sufficiently to prove that as long as the pylorus remains permeable, the stomach has an almost invincible tendency to drive out its contents through this orifice without being inclined to utilize the artificial mouth. Nothing whatever passes through the new opening; on the contrary, everything passes through the pylorus."

CANNON, who studied this subject in a large series of animal experiments, came to the following conclusions: "The idea that gastro-enterostomy represents a drainage operation is wrong. There can be no doubt that in animal experiments the natural exit of the food is through the pylorus and not through the artificial opening, when both ways are offered for the passage of the food."

The same author in a thorough study, published some years previously with Blake, states that in the presence of a patent pylorus the food leaves through the pylorus rather than through the gastro-enterostomy stoma, no matter where the stoma is placed or how large the latter is made. Factors of peristalsis, pressure-relations and difference of food consistency in the cardiac and pyloric portions of the stomach make the pyloric passage a more natural exit than the artificial opening in other parts of the stomach.

HAERTEL observed, in a large series of radiographic observations, that the peristaltic wave of the stomach is unchanged after gastro-enterostomy. It is still directed toward the pylorus. He states that following gastro-enterostomy the food passes in equal parts through the pylorus and the stoma. Schueller's and Petrén's conclusions coincide with Haertel's views.

Outland, Skinner and Clendenning, on the other hand, came to entirely different conclusions. They claim that their röntgenographic experiments prove that gastro-enterostomy is a drainage operation and prevents the passage of food through the pylorus.

Thus, with the exception of Outland, Skinner and Clendenning, all authors above quoted agree that a considerable quantity of food passes through the pylorus, even in the presence of a patent stoma. Such a state of affairs is certainly not desirable. The healing of the ulcer will certainly be hastened considerably if, at least for a certain length of time, the food can be completely and surely sidetracked. Different authors have suggested different forms of pyloric exclusion. In a former paper on this

subject I have described the different methods of exclusion. I shall therefore refrain from discussing the relative value of these methods at length. The unilateral exclusion (Eiselsberg) and a modification of the Biondi method described in my previous paper on this subject are the only methods which guarantee a permanent exclusion. However, a temporary exclusion is sufficient to cure the ulcer. The exclusion stitch, introduced by Berg into clinical surgery, is the simplest and safest method of exclusion.

Berg's method is described by him in the following manner: "A double Pagenstecher linen suture, armed with a needle, is carried around the posterior stomach wall and is held in place by taking several bites in the anterior wall of the stomach. The suture is then tied and the pylorus thus occluded; the knot is buried by a few single stitches."

There is no doubt that röntgenography is a very good method to study the passage of the food following gastro-enterostomy. By this method, however, only short phases of the process are observed, as it is impracticable to watch the whole cycle from the time of intake of the food until complete emptying has occurred. Merely snapshot pictures are obtained, taken at different periods. At some future date this gap may be filled by röntgenographic motion pictures. Furthermore, some of these observations are rather doubtful as to their correct interpretation.

There is, however, a much simpler method which will demonstrate in permanent and preserved form the passage of the food through pylorus and stoma respectively. This method consists in the employment of stained fluids.

The choice of these fluids is a very limited one. In fact, among all the innumerable dyes, thionine blue represents the only one which answers our purpose. The mucosa of the stomach and intestines is covered with a rather thick layer of mucus. For this reason the dye to be employed must have a specific affinity for mucus. Methylene blue, for instance, will pass through the gastro-intestinal tract without coloring the wall, mixing only with the faeces. Another coloring medium which was tried first (*i.e.*, lamp-black) showed the same quality (intense colorization of the faeces without a trace of color on the mucous membranes).

Thionine blue, on the other hand, has a specific affinity for mucus. The first series of experiments was made with the German preparation which gave a dark blue color. The final experiments were made with an American product, as the foreign product was not obtainable on account of the war. This American product, though just as efficient, colored the specimens greenish instead of dark blue.

The experiments were performed in the following manner: Dogs were anaesthetized and a suture gastro-enterostomy or a suture gastro-enterostomy plus pyloric exclusion was performed. Two days after the operation 300 c.c. of a 2 per cent. thionine solution were injected into the stomach through a tube. The dogs were killed under chloroform anaesthesia on the following day.

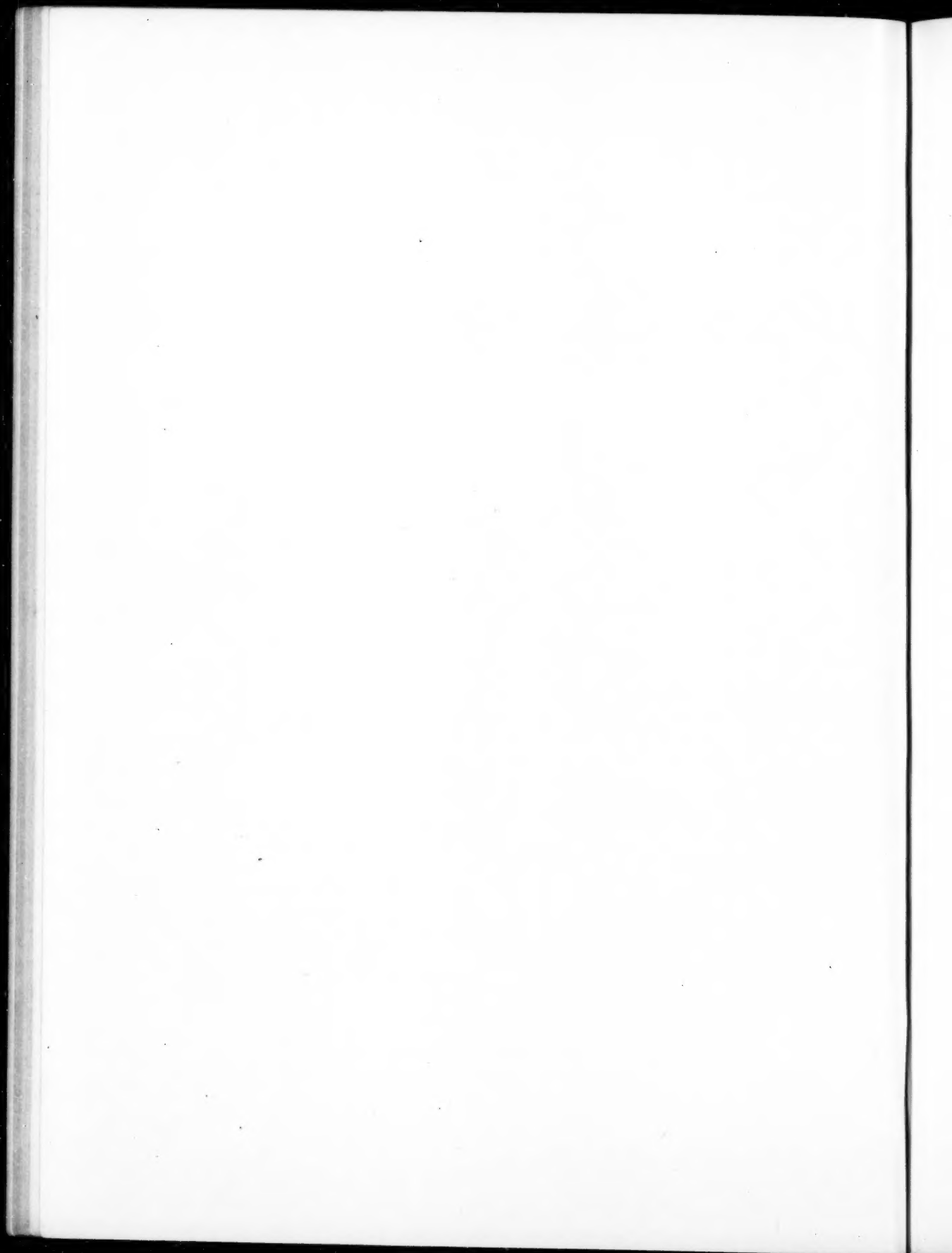


FIG. 1.—Gastro-enterostomy with pyloric exclusion. (Surg. Path. 4355.)



FIG. 2.—Gastro-enterostomy without pyloric exclusion. (Surg. Path. 4340.)





## THE VALUE OF PYLORIC EXCLUSION

The difference in the coloring of the duodenum in the excluded and non-excluded specimens is very obvious (see Figs. 1 and 2). In the first specimen (gastro-enterostomy and pyloric exclusion) the stomach mucosa and the jejunum distal to the stoma show a dark greenish color. The duodenum shows only a slight trace of color. In other words, the exclusion caused practically all of the thionine solution to be driven directly from the stomach into the jejunum without passing the pylorus. The slight trace of thionine solution in the duodenum is explained by the fact that the tobacco-pouch formation of the excluded pylorus allowed a few drops of fluid to pass through into the duodenum. Berg's exclusion is not complete for fluids. However, it prevents solid food absolutely from passing through the pylorus.

In the other specimen (gastro-enterostomy without pyloric exclusion), stomach, duodenum and jejunum show a dark green color of the same intensity. Evidently the solution has passed in about even proportions through the pylorus and the stoma.

This experiment thus demonstrated *ad oculos* the efficient way in which this simple method sidetracks the food.

It must be clearly understood that this series of experiments investigated the mechanical results which follow gastro-enterostomy. The changes produced in the chemistry of the stomach after gastro-enterostomy were not considered in these experiments. It is a well known fact that, following a gastro-enterostomy, bile and pancreatic juice are regurgitated through the stoma into the stomach, thus diminishing the hyperacidity considerably. This change of the chemism of the stomach is of the utmost importance. In fact, we believe that improvements in the clinical condition after gastro-enterostomy without pyloric exclusion are based solely upon the changes of the chemistry of the stomach. Gastro-enterostomy plus pyloric exclusion is however far superior to simple gastro-enterostomy. It gives the patient the benefit of the chemical changes just mentioned and, in addition to that, it safeguards the ulcers against mechanical insults, thus hastening the healing of the ulcer-bearing area.

I have shown in the paper above mentioned that pyloric exclusion does not exclude the pylorus permanently. However, the exclusion persists long enough to effect a rapid cure of the ulcer. It may be very advantageous that pyloric exclusion is of temporary nature only and that after the healing of the ulcer the normal passage of the food through the pylorus is partly restored. For it has been proved that hydrochloric acid will be neutralized much less efficiently if it passes from the stomach directly through the stoma into the intestines than if it takes its route *via* the duodenum. Diarrhoea, frequently encountered after gastro-enterostomy, is probably due to the action of the insufficiently neutralized hydrochloric acid on the intestinal mucosa.

The exclusion stitch does not add in any way to the risks of the operation. No accidents following its use have ever been recorded. Its proper application does not require more than a few seconds. It certainly improves

the chances for a rapid disappearance of the distressing symptoms caused by pyloric and duodenal ulcers.

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## IMMEDIATE JEJUNAL FEEDING AFTER GASTRO-ENTEROSTOMY

BY ALBERT F. R. ANDRESEN, M.D.  
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It is generally conceded that the sooner after any operation a patient can be supplied with an adequate amount of fluid and nourishment, and the sooner the normal gastro-intestinal peristalsis can be reestablished, the better are the chances of the patient for recovery. But this is especially true after gastro-enterostomy for pyloric stenosis, when the patient is usually suffering from starvation which has been allowed to go on for a considerable time, so that not only are the tissues dried out from lack of fluid, but there is also a varying degree of acidosis. These patients, whether suffering from a carcinoma or an indurated ulcer, are usually from thirty to fifty pounds under weight and make exceedingly poor operative risks. When the obstruction is not complete, duodenal, or fractional gastric feeding, by the author's method, together with rectal alimentation and subcutaneous fluid, will often transform an inoperable case into an operable one, but even then the shock of the operation, the exhausting and drying-out effects of the anæsthesia, and the paralyzing effect of handling on the already weakened peristaltic action of the intestine, combine to make the mortality excessively high. The Murphy drip, while of inestimable value in these cases, is not always sufficient to save life, and lavage does not always prevent gastro-intestinal ileus. The usual period of post-operative starvation adds to the complications. The writer has found that it is practicable, at the time of operation, to insert a previously swallowed Rehfuß gastroduodenal tube well into the jejunum and to commence at once, on the operating table, the feeding of peptonized milk, dextrose and alcohol mixtures, thus making sure that the nourishment administered actually is made use of by the body. The method is as follows:

For a day or two, or as long as possible before operation, the Rehfuß tube is left in the stomach day and night, so that the patient may become accustomed to the slight irritation it occasions in the throat, and not pull it out when still under the influence of the anæsthetic. If the stenosis is not complete, or if the operation is being performed for a non-obstructing ulcer, the tube may advantageously be employed for duodenal or gastric feeding, while other preparations are being made for the operation. At the time of operation, which, especially in debilitated patients, should be performed under local anæsthesia, the usual type of gastro-enterostomy is done, but before closing the stomach, the metal tip of the tube is fished out and inserted at least fifteen or twenty centimetres down in the jejunum. The opening is then closed in the usual way. Feeding is commenced at once, on the table, about two hundred or two hundred and fifty mils being given very slowly through a funnel. The fluid should be at a temperature of about 105° F., and may contain whiskey, coffee or other stimulant as required for immediate stimulating effect. Feedings may thereafter be

given by the continuous drip method, but the writer prefers to have the nurse give a definite amount at a definite temperature at regular intervals, thus avoiding any uncertainty such as is occasioned by accidents to the drip apparatus. Two hundred mls of peptonized milk, with fifteen grammes of dextrose and eight mls of whiskey, given at two-hour intervals, will furnish over twenty-five hundred calories in twenty-four hours. The feedings may be given, without awakening the patient, day and night.

So far as the writer knows, this method was first used at the suggestion of the writer, at the Brooklyn Hospital in October, 1917, Dr. Walter A. Sherwood being the surgeon who performed the operation. It was tried twice within a week, the first patient being operated upon for a carcinoma, the second for a large indurated ulcer, a complete pyloric stenosis being present in both cases. The first case was a woman seventy years old; the second, a man of fifty-two, both being in very poor condition, with evidences of myocardial degeneration and marked signs of retention from a chronic nephritis of probably considerable duration. In the first patient the tube was pushed but eight or ten centimetres into the jejunum, with the result that the patient vomited the tip of the tube after about thirty hours, but not until about 3000 calories, in nearly four litres of fluid, had been retained in this way. Feedings by mouth were then immediately begun, and the patient made an uneventful post-operative recovery, without ever having exhibited any symptoms of shock. In the second patient, the tube was inserted twenty centimetres into the jejunum, with the result that it was not vomited. The tube was left in for three days, the patient receiving between 2500 and 3000 calories per day during that period, and making a rapid recovery. In neither case was rectal alimentation considered necessary and no hypodermatic stimulation was required. The first patient had a spontaneous bowel evacuation on the second day after operation. The second patient, who at operation was found to have a dilated, atonic colon, was given powdered aloes through the tube, at once, and pituitary liquid hypodermatically, with excellent result. With the abdomen still open, the effect of injecting the fluid into the traumatized jejunum was observed. The first one hundred mls of fluid distended the jejunum, almost back to the gastrojejunos-tomy stoma, but then there occurred strong peristaltic contractions, which rapidly pushed the contents downward, so that by the time the full amount had been given the jejunum was empty. This demonstrated that our two-hour intervals are extremely conservative, much more frequent feedings being possible.

The writer considers that he has demonstrated that immediate jejunal feeding after gastro-enterostomy is not only a safe, but an extremely valuable, procedure, and is to be recommended not only in the operations performed for stenosis, but should be tried in all types of cases, as being a more certain, and, in most cases, a less uncomfortable method of post-operative administration of fluid and nourishment than the methods ordinarily employed.



## DEVELOPMENTAL RECONSTRUCTION OF THE COLON\*

ANIMAL RESEARCHES AND CLINICAL REPORT OF TWENTY-NINE HUMAN CASES

BY JOHN WILLIAM DRAPER, M.D.

OF NEW YORK

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COMPARATIVE anatomy sheds an interesting and instructive light upon the development of the human colon. Huntington,<sup>1</sup> discussing primitive types and in particular the terminal straight segment of the canal which is so much shorter in many vertebrates than in man, says: The primitive condition of the intestinal canal may be observed in some members of man's own class, the mammalia, as in certain edentates. Notable among these is the little ant-eater of Brazil. The termination of the duodenum and the bend in the colon mark the two points at which in the primitive scheme the umbilical loop begins and terminates. These two points we can describe as the duodenocolic neck or isthmus. In the snapping turtle the same condition prevails, namely the duodenum and the colon approach each other very closely at the isthmus and between these points the convolutions of the intestine extend in a wide circle. "We will find this approximation of duodenum and colon a feature which persists throughout all the later developmental stages of the higher vertebrates and has an important bearing on the final arrangement of the intestinal canal in the human adult."

Thus, not only throughout the fish, the turtles and the frogs, but actually in man's own class, we find types in which the adult corresponds in colonic position and limitation of growth to the primitive form.

Anatomy and embryology are not alone in giving important information as to the relative value to the human organism of the right and left sides of the colon. In a paper read before the section on Pathology and Physiology of the American Medical Association, 1914,<sup>2</sup> I have called attention to the relative inactivity of the right or oral colon in the dog as regards the excretion by it of drugs and toxins compared with the activity of the left or aboral portion of the organ. Briefly, it has been noted by us in company with many others, that even in an animal like the dog, in which there is normally no ascending colon and a rudimentary cæcum, there is a vast difference between the excretory activity of the cæcocolonic region and the caudad portion of the organ. In pilocarpine or diphtheria poisoning, or in the toxæmia of

\* Read before the American Gastro-enterological Association, Atlantic City, May, 1917.

<sup>1</sup> The Anatomy of the Human Peritoneum and Abdominal Cavity, p. 56.

<sup>2</sup> Draper, J. W.: Studies in Intestinal Obstruction. Journal A. M. A., September 26, 1914, p. 1079.

duodenal obstruction, the oral portion of the colonic mucosa remains normal in color while the aboral assumes a brilliant scarlet.

A third avenue for the approach of this interesting problem of colonic variability is found in clinical study at the operation table on adult human beings. It has long been known to biologists that variations in form attest to recency of origin and instability in function. What thoughtful surgeon is there among us who has not been repeatedly struck with the amazing variations in form on the right side of the colon as contrasted with their absence on the left. The occasional exception to this occurs only in the pelvic colon. Moreover, not as a rule having had opportunity for the study either of embryology or of comparative anatomy, he has been at a loss to comprehend or to make any reasonable interpretation of these variations.

It was only after many years' consideration of these abstract phenomena that my colleague, Jerome Lynch, and I became interested in the possible meaning attached thereto and as to whether any utilitarian application thereof could be made in improving the therapeutics of human disease. Especially after reading Madison Grant's notable book,<sup>3</sup> however, we are more than ever convinced that such utilitarianism, be it in pedagogy, in medicine or in other walks of life, is one of the poorest, if not the very worst, characteristic handed down to us from the Nordic race and of very secondary value as compared with search for the abstract truth. We hold with increasing tenacity that no lasting progress can be made in medicine except by approaching its great problems solely from the standpoint of pure science. As Le Père Felix says: "*Nos progrès sont pleins de la sueur des siècles passés.*"<sup>4</sup> It is in every case an idealist, a Pasteur or a Hunter, who has furnished the framework upon which materialism has built.

In a recent unpublished address before the New York Academy of Medicine the English physiologist, Haldane, said that the modern mechanical methods in physiology had about reached the limit of productivity and that a return would shortly be made to some of the methods previously in vogue, and long since discarded by the mechanistic school, notably the theory of vitalism and its allied branches. We are at the parting of the ways.

From our laboratory and clinical studies we are convinced that our provisional hypothesis regarding the cæcocolon, its relative unimportance and frequent danger to the human economy, based as it was upon biologic premises, is correct. Our clinical data and our experimental studies agree with these premises. The two support each other. Bryant's studies,<sup>5</sup> resulting in a classification of human beings and disease into herbivorous, neutral and carnivorous types, as well as the well-known work upon right colonic resection and exclusion of Bloodgood, Mayo, Ochsner, Satterlee and others, compel the general attention of the profession to the cæcocolon. The far-

<sup>3</sup> The Passing of the Great Race.

<sup>4</sup> Conférences de Notre-Dame de Paris.

<sup>5</sup> Bryant, John: The Carnivorous and Herbivorous Types in Man. Boston Medical and Surgical Journal, September 9, 1915.



Fig. 1.—Dog 174. Control meal showing residue in stomach.

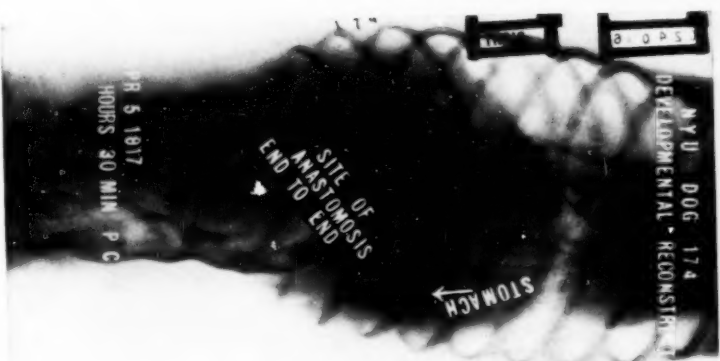


Fig. 2.—Dog 174. After reconstruction end-to-end anastomosis. No delay, but high mortality.

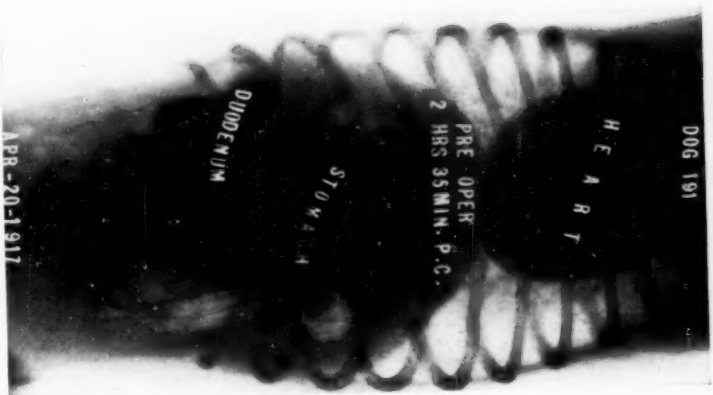


Fig. 3.—Dog 191. Before developmental reconstruction of the colon: end-to-end anastomosis. Note the disproportionate size of the heart shadow in the dog as compared to the human.

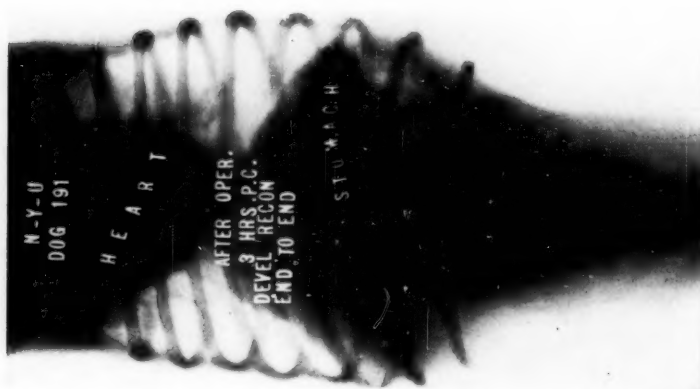


FIG. 4.—Dog 191. After developmental reconstruction of the colon: end-to-end anastomosis.

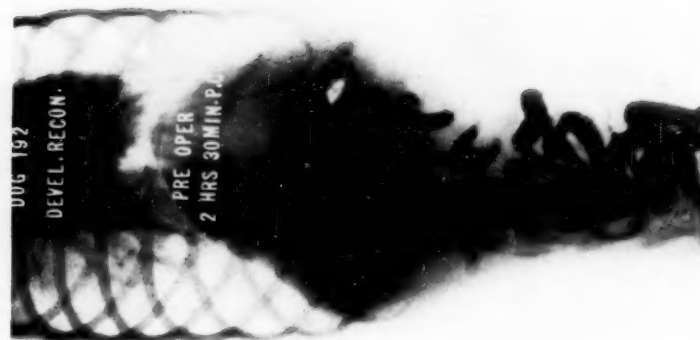


FIG. 5.—Dog 192. Before operation.



FIG. 6.—Dog 192. After operation for developmental reconstruction by lateral anastomosis.

## DEVELOPMENTAL RECONSTRUCTION OF THE COLON

reaching variations in the syndrome of human symptoms, varying in all grades from the neuromental to the arthritic, and which in properly chosen cases are cured or improved by right-sided resection, show the problem to be one of the most fundamental in all medicine. Obviously, it can be solved only by the combined efforts of both clinical and biological workers; the bioclinician having naturally the greatest opportunity for success.

### EXPERIMENTAL STUDIES

These were made on dogs and were, of necessity, limited in scope, owing to the embarrassing fact that the ascending colon is normally lacking in the dog, and that like the ant-eater its duodenum and colonic bend are closely approximated. Thus the colon is exceedingly short and affords but limited chance for operative procedure. We have been, therefore, confined to a technical consideration of the effect of the modified developmental reconstruction which is possible in the dog upon the motility of the stomach as shown by X-ray and upon the relative merits of the lateral, the end-to-side, and end-to-end forms of anastomosis, as observed by the same agent. The accompanying table is self explanatory and supports in general what has been the usual holding in human surgery: that whereas the end-to-end technic gave the most ideal result, its high mortality made necessary a choice of either the lateral or end-to-side implantation.

DEVELOPMENTAL RECONSTRUCTION

Before operation			After operation			
	Elapse of time between meal and X-ray	Remarks—stomach emptying	Elapse of time	Remarks		Number of days post-operative
				Stomach emptying	Anastomosis emptying	
<b>A</b>						
End-to-end anastomosis, 3 cases:						
1. Dog 170....	2 hrs. 50 min.	Slight residue	3 hrs. 20 min.	Normal	No delay	7
2. Dog 174....	3 hrs. 40 min.	Slight residue	3 hrs. 25 min.	Delay	No delay	13
3. Dog 191....	2 hrs. 50 min.	Slight residue	3 hrs. 20 min.	Delay	No delay	14
<b>B</b>						
Side-to-side anastomosis, 3 cases:						
1. Dog 175....	3 hrs. 40 min.	Empty	3 hrs. 20 min.	Marked delay	Slight delay	10
2. Dog 192....	2 hrs. 50 min.	Slight residue	3 hrs. 40 min.	Marked delay	No delay	12
3. Dog 203....	3 hrs. 0 min.	Empty	3 hrs. 0 min.	Marked delay	No delay	12
<b>C</b>						
End-to-side anastomosis, 3 cases:						
1. Dog 186....	3 hrs. 5 min.	Residue	3 hrs. 15 min.	Moderate delay	No delay	13
2. Dog 198....	3 hrs. 10 min.	Residue	3 hrs. 10 min.	Slight delay	Delay	10
3. Dog 206....	3 hrs. 5 min.	Residue	3 hrs. 5 min.	No delay	No delay	6

No surgical research on animals can possibly be made without the conclusion that the persistence in man of the right colonic segment which has come to us apparently through the dominance of its experimental lengthening by the herbivora is ill adapted to our needs. Just what relation the upright position may have to the frequency of localized right-sided constipation, we are not prepared to say, because so little is known of the relations between gravity and intra-abdominal pressure. Constipation unquestionably is merely a part of the protective bodily mechanism. Having learned largely through Barber's researches\* that gravity has little or nothing

\* Barber, W. H.: Segmental Resection for Gastric Ulcer. *ANNALS OF SURGERY*, November, 1916.



to do with the emptying of the stomach after gastro-enterostomy, stoma position and neuromuscular gastric condition being the true determining factors, we are very loath to place much credence in the popular but ill supported theory that the human cæcum often does not empty because of gravity. We are, of course, ready to concede that this factor has its place in the causative syndrome, but realizing the markedly close analogy both as to physiology and as to morphology which exists between the stomach and the cæcum, and to which we have repeatedly referred in previous articles,<sup>1</sup> we feel quite certain that the gravity hypothesis is at best inadequate. Our hesitancy is further increased by the findings of our colleague, McFarland, whose pathological studies<sup>2</sup> of the cæcocolons removed by us show the tissue to present certain atypical characteristics, notable among these being the frequent presence of pigment. This we regard as a highly important contribution. This affords additional basis for the assumption that an inherent biological instability of the cæcocolon as developed in man is more responsible for the symptoms which unquestionably arise from it than the effect upon its emptying by gravity. There is undeniable decadence in function in all organs developing in the higher types in late fetal or early extra-uterine life. We must all remember that colonically speaking we are dogs at birth, the colon reaching only to the liver—thus the left colon, excepting only the pelvic portion, is of extreme age, of constant and important function, of fixed morphology as compared with the right which has not these important attributes. May it not be more logical to consider the relative importance of the right and left sides from the broad standpoint of phylogeny rather than from the narrow viewpoint of descriptive anatomy, and to base our therapeutics upon known biological laws rather than upon unproved and very questionable clinical hypotheses? This must be even more acceptable if the biological laws prove to be supported by our clinical therapeutics in individual human beings. Thus the cæcocolon may be considered the decadent wisdom tooth of the alimentary canal and be treated as such.

## CLINICAL REPORT

In twenty-nine human cases of developmental reconstruction of the colon five have died, a mortality rate of 17 per cent. An analysis of this mortality is proper at this point because its degree would be deterrent and properly so in the employment by others of this operation. Four deaths occurred in the first eight cases. One death in the last twenty. An analysis shows two important facts. First, that we did not understand how to choose the cases. Second, that our technic has improved. The cause and time of death in the five cases is as follows: In two, both of them epileptic, shock in less than twenty-four hours after operation. In one, hemorrhage six hours after operation. In one, septicaemia, four weeks after operation. Autopsy showed an old perinephritic abscess, unrecognized at time of operation, as probable cause of death. One in a debilitated derelict, five days after operation, peritonitis. We have eliminated much of the post-operative shock by careful avoidance of all traumatism to the nerve centres near the duodenum. The post-operative hemorrhage death was due to the nurse's failure to report patient's condition until too late. The perinephritic abscess case in which death occurred four weeks after operation and in which all bowel functions

<sup>1</sup> Lynch-Draper: The Protective or Esoteric Symptoms of the Alimentary Canal. *Virginia Semi-Monthly*, March 24, 1916.

<sup>2</sup> McFarland, W. L.: Pigmentation of the Hind Gut. *Journal A. M. A.*, December 8, 1917.

## DEVELOPMENTAL RECONSTRUCTION OF THE COLON

had been completely restored to normal, should not be charged against the series except in an indirect manner. Reclassifying the cause of death, therefore, we find that peritonitis, due directly to leakage from the anastomosis, caused one death, or 3.4 per cent. Shock in two epileptics, or 6.8 per cent.; septicæmia from long standing infection, one death, or 3.4 per cent.; accidental hemorrhage, one death, or 3.4 per cent. This analysis is in no way an attempt to minimize the danger and gravity of this operation, which we feel sure should not be undertaken except after the most exhaustive studies, until competent and long-continued medical care has proved unavailing, and then only by an experienced operator.

Effects of developmental reconstruction upon the patient's symptoms. In order to study these it is necessary to make an attempt at symptom grouping. For our purposes a classification of the patients into two general groups has served the purpose. The first, and by far the larger group, may be termed the "neuromental"; the second, much smaller, the "arthritic." This is an arbitrary setting which perhaps should be discarded and can no doubt be improved upon.

Something should be said regarding the methods employed to group the cases and to reach a decision as to operation. We consider it imperative that each patient should be studied by X-ray, and that the operation is indicated in exceedingly few cases that do not show cæcocolonic delay of 100 hours or more. The symptoms certainly are not due to constipation which we regard definitely as a protective symptom, but rather to the diseased state of the cæcocolon which permits passage of toxins arising either from bacteria or from the gut wall itself. This latter occurs in duodenal obstruction—why not in colonic? Satterlee's studies<sup>9</sup> of the chemical blood picture in colonic toxæmics (human) are of the utmost value and interest, tending, as

### RESULTS OF EXAMINATION OF CASES OF CHRONIC INTESTINAL TOXÆMIA IN WHICH BLOOD WAS EXAMINED CHEMICALLY

Non-protein nitrogen .....	Over normal (45 mg. per 100 c.c.).....	14 cases
	Under normal (30 mg. per 100 c.c.).....	6 cases
Urea nitrogen .....	Over normal (25 mg.).....	4 cases
	Under normal (15 mg.).....	6 cases
	Normal .....	10 cases
Uric acid nitrogen .....	Over normal (3.5 mg.).....	4 cases
	(highest 10.49 mg.)	
	Under normal (1.0 mg.).....	8 cases
	Normal but with subsequent rise.....	1 case
	Under normal with subsequent rise.....	1 case
	(sudden gout)	
Creatinine .....	Over normal (0.5 mg.).....	12 cases
	Under normal (0.1 mg.), sudden rise....	1 case
	Normal (0.1-0.5 mg.) .....	7 cases
Blood sugar .....	Over normal (120 mg.).....	6 cases
	Under normal (50 mg.).....	0 cases
	Normal (50-120 mg.) .....	14 cases

<sup>9</sup> Personal communication.

the accompanying tables show, to indicate that a toxic element arises under conditions of partial or complete obstruction of the terminal gut similar in effect to that of duodenal obstruction, already published by me.

We also regard as imperative not only the removal of all possible areas of infection due to local foci, tonsils, teeth, crevices, etc., but even more particularly the repair of any and all local lesions such as hernia, hemorrhoids and the like, which may have important bearing through reflex inhibition of the right side of the colon. Needless to say, every case should be put through a complete laboratory study, including the Wassermann reaction. In one of our cases this, unfortunately, was not done, dependence being placed upon a 100-hour right-sided X-ray delay. Developmental reconstruction reduced the barium oro-anal time to thirty-six hours, due to the fact that the operation had enabled us to remove an extensive area of partial obstruction at the hepatic flexure—Lynch's "elbow deformity." The patient's symptoms of pain, referred to the rectum, however, persisted until we all, as he said, thought it was "in his head." An "*ex post facto*" Wassermann, however, was three plus.

Our earlier cases now date back nearly three years. The greater number are over one year and a half, the most recent is three months. It is, therefore, probably justifiable to present some utilitarian deductions based upon subjective and objective data. Careful and conservative study of the twenty-four living members of this interesting series shows at the very least a 75 per cent. improvement in efficiency and subjective symptoms. Incidentally, the more we study these cases the greater respect we have for the subjective testimony. The extraordinary accounts by these highly neurotic and often unbalanced patients have in the past been looked upon as worthless, but we have come to regard them with great respect, having often found at operation objective corroboration. Truly, as William Mayo has well said, in rejecting such testimony as a worthless fable, we ourselves are indeed the fool rather than the patient.

*Technic.*—We have resected the terminal 10 cm. of the ileum and the cæcocolon in block to the neighborhood of the right colic artery. This corresponds to a point upon the transverse colon near to the right margin of the omentum. Since in practically all of our cases there has been a common mesentery of the cæcum and ileum so that the entire mass, particularly after careful separation of the mesenteric leaves, could easily be lifted above the belly wall so that both the resection and the anastomosis was done extra-abdominally, we have been able to avoid shock by keeping away from the duodenal centres. Keith's centre at the terminal ileum, while doubtless in close and important neuromuscular relationship with the duodenal centres, as proved by the interesting and conclusive experimental researches of Barber, may apparently be removed without adding surgical shock. This does not mean, however, that we consider ourselves at all informed as to the final post-operative result of its loss to the economy.

## DEVELOPMENTAL RECONSTRUCTION OF THE COLON

### CASE HISTORIES: NEUROMENTAL GROUP

Mrs. R. B. E., aged twenty-eight. This intelligent woman is from the professional ranks and has had the best medical care. She was operated on two and a half years ago. Two healthy children, eight and ten years old. Chief complaint: Chronic constipation associated with extreme mental depression—suicidal; in the State Insane Asylum, Waverly, Mass., six years ago for six months. Husband was told by the alienists that she never could be cured; a hopeless mental case. Now reports herself 80 to 90 per cent. improved and able to care for her household and social duties; bowels regular; no cathartics. When presented recently before the Medical Progress Club of New York she replied to an inquiry as to what her chief trouble had been before the operation, "trying for fifteen years to keep from losing my mind."

Miss A. J. L'E. This woman is a descendant of an old Belgian family and knows her mind. Before operation she had been in the hands of a trained nurse under the most competent medical supervision that money could obtain. She had travelled with the nurse from the Gulf of Mexico to Labrador in the vain search for health. She was regarded by her family and attendants as deranged. Without provocation she flew into the most violent fits of uncontrollable rage. It was impossible for her to associate with anyone. She complained of the most frightful headaches, hemicranial in type. Her bowels were irregular, constipation alternating with diarrhoea. Two years and eight months ago developmental reconstruction was done. Her cæcocolon was grossly and microscopically atypical, being filled with pigment, and the mucosa being nearly destroyed. That this woman's symptoms were directly attributable to the absorption of unknown products from this degenerated and sac-like bowel segment is undeniable, for not only has she returned to her arduous work of teaching, but her headaches are 95 per cent. diminished, her bowels are regular, and she is able to associate with her fellow beings.

Mrs. M. E. R. This woman, forty-four years of age, was for years a chronic sufferer with hemicranial headache; in bed for five days with each attack. In 1909 she had 67 headaches; in 1910, 59; in 1911, 65; in 1912, only 35 (this she attributed to rigid abstinence from meat); in 1913, 49; in 1914, 50; in 1915, 65 (the diet had been rigidly maintained, but the headaches had now reached their former maximum). Developmental reconstruction six months ago. Constipation cured; one headache only, which patient attributed to her over-indulgence socially. Of particular interest from a biochemical standpoint is the fact that she has added both meat and eggs to her diet. For the past six years she had not been able to eat an egg without being certain of having a headache.

### ARTHRITIC GROUP

We have had but one case presenting uncomplicated multiple arthritis. We offer no explanation for this curious evidence of selective action of the toxins. It has happened that this case was evidently well chosen, for she has been rendered 80 per cent. efficient by develop-

mental reconstruction of the colon. While the arthritis was marked in the lower extremities, the patient could still walk by a sort of creeping gait. She had not been able to feed herself except occasionally with a spoon for over two years. She had not been able to turn over in bed for two years; she had not been able to write for three years. After every possible source of infection had been sought for elsewhere, it was decided that the toxins were being distributed from her colon where she presented 100-hour right-sided delay. Seventeen months ago developmental reconstruction was done. In thirty-six hours the patient affirmed that every vestige of pain had left her body and that it was the first time in three years that she had not suffered pain day and night. More remarkable to us was the change about the small joints. How the scarlet color could be blanched as it was in thirty-six hours still remains a mystery. We are aware that Bottomley and others have not had as gratifying results as we are able to report in this case. Whatever the future of this individual may be as to relapse and recurrence, the study of her post-operative condition is of the utmost value in proving that in her case at least the toxins did come from a diseased cæcocolon.

#### INDICATIONS FOR DEVELOPMENTAL RECONSTRUCTION

1. Segmental infection of the cæcocolon. Like any other infected hollow organ it is a constant source of danger.
2. In Lynch's elbow deformity of the mid-ascending colon when the peritoneum cannot be repaired after reduction.
3. In exaggerated non-fusion of mesentery, allowing such freedom of motion as occasionally to result in volvulus. This happened in one of our series.

#### CONCLUSIONS

1. Developmental reconstruction of the colon is an operation which finds justification in heredity, in well-known laws of biology and in clinical study.
2. It is a procedure fraught with danger and one which never should be undertaken until, not alone exhaustive studies have been made, but until modern and well-directed medical therapeutics has failed.
3. Ileosigmoidostomy is unphysiologic and has therefore failed.
4. The subjective symptoms for which the operation is indicated are usually neuromental; the objective symptom is cæcocolonic degeneration. The degree of improvement in our series is amply sufficient to justify the operation in selected cases.
5. Developmental reconstruction has superseded in our clinic all the earlier forms of operative procedure such as ileocolostomy, cæcosigmoidostomy, etc., because we have found it to be no more dangerous operatively and to give better results because it removes the biologically decadent and diseased organ and restores the individual to the carnivorous type of colon undoubtedly best suited to man.



## OMPHALOMESENTERIC DUCT: INTESTINAL OBSTRUCTION

By MERVIN T. SUDLER, M.D.

OF ROSEDALE, KANSAS

PROFESSOR OF SURGERY IN THE UNIVERSITY OF KANSAS

OBSTRUCTION due to Meckel's diverticulum and the various bands and remains of the omphalomesenteric duct is usually of a serious character; because the obstruction is usually of such a type as to involve a loop of the small intestine; and the result becomes serious very rapidly for the patient. A large number of the different varieties of obstruction that can occur have been reported and collected; but the following case seems to be sufficiently unusual to be worthy of report.

January 4, 1917. Case referred by Dr. James D. Lee, Eudora, Kansas.

Patient is a young man, twenty-four years of age. His umbilicus shows as a scar, rather smooth, and not depressed. His father states that he had trouble with it as a child; and that it did not heal until he was four years of age. He has also had attacks of pain on the right side of the abdomen which required a hypodermic injection of morphine for relief. Usually, one injection was sufficient and recovery was prompt. Exercise apparently has something to do with the attacks; and he has been unable to work on account of them. During these attacks he frequently vomited.

Thirty-six hours ago this attack began; and instead of one hypodermic sufficing, several were used; but he grew steadily worse. His bowels moved twenty-four hours before admission to the hospital.

Upon admission to the hospital, his temperature by mouth was normal; by rectum it was 99.8. Before leaving his home, eight miles away, for the hospital, his pulse was about 80 and of good quality. He arrived at the hospital about ten o'clock in a state of collapse, and his pulse could be felt only occasionally and with difficulty. His color, however, remained good.

Under light ether anæsthesia, an appendix incision was made, as his pain had been in this region. When the abdomen was opened a large amount of bloody fluid escaped; and a large part of the ileum, extending from a point about six inches above the ileocaecal valve upwards, was gangrenous. The strangulation was caused by a constricting band about nine centimetres long and about five millimetres in diameter. The smaller end of this was attached to the ileum. The other end (about two centimetres long) was cystic and dilated, was attached just under the umbilicus. This was twisted as shown in the illustration (Fig. 1)—a loop had evidently formed and the intestine had slipped through. The gangrenous intestine was hastily resected, the distal end of the intestine closed, and the proximal end drawn out of the incision

and fastened by a few catgut stitches. While this was being done, the patient's pulse was at times imperceptible; and 700 c.c. of normal salt solution were given subcutaneously. The resected bowel measured 56 inches (140 centimetres) in length. When seen the following morning the patient had taken a glassful of water and was not nauseated; and apparently there was some peristalsis. The dressings were saturated with serum. The pulse was 130, easily counted, and of good quality. The patient's recovery from this operation was rapid and uneventful.

On January 16, twelve days following the previous operation, the patient had no fever, and his pulse was normal. The incision appar-

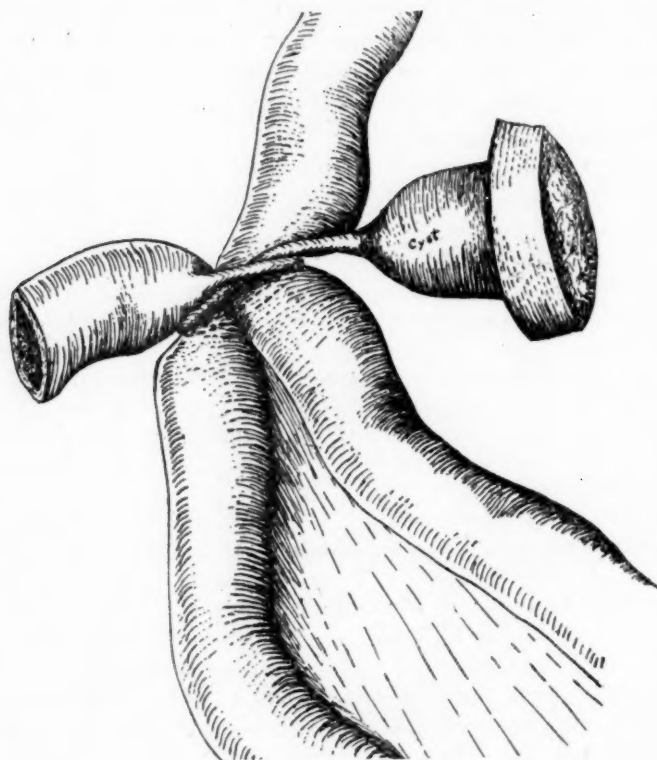


FIG. 1.

ently healed by primary union. An effort was therefore made to anastomose the ileum with the ascending colon and so restore the continuity of the intestinal tract. Under ether anæsthesia, an incision was made through the rectus muscle just internal to the one through which the resection had been done. Immediately upon opening the abdomen about two cubic centimetres of frank pus escaped. There were quite a number of adhesions. The small intestine, which had been brought out of the abdominal incision, was next freed, and the end closed over, first by a continuous stitch and then by a purse-string suture. The intestine in the upper part of the abdomen seemed to be perfectly

## OMPHALOMESENTERIC DUCT: INTESTINAL OBSTRUCTION

free. The ascending colon was freed with some difficulty. A lateral anastomosis was done about two and a half inches above the lower end of the cæcum. The mesentery held the small intestine so that it was not turned; but the resected end pointed downward. The patient left the table in good condition, having a pulse of 110.

Considerable reaction followed this operation, though the patient's condition was never serious. Eleven days following, a small fecal fistula developed. The patient was discharged from the hospital twenty days later, having a granulating area five centimetres square, and a small amount of fecal drainage. The bowels moved naturally, and the pulse and temperature were normal.

On May 16, 1917, as a little fecal drainage still persisted, the sinus was closed under ether anæsthesia.

In February (thirteen and a half months following the operation) he had gained twenty pounds and was feeling well. He had no further digestive disturbance and has been doing farm work without difficulty, and without his old intestinal symptoms appearing.

## CLOSURE OF THE ABDOMINAL INCISION\*

By CHARLES G. CHILD, JR., M.D.

OF NEW YORK

(From the City Hospital Reports)

IN the closure of every abdominal incision, one immediate and most important indication must be met—the prevention of primary hernia. Does the almost invariable custom of closing the wound with absorbable material meet this indication? To my mind, it does not; and I believe that it leaves much to be desired along other lines as well. In the early days of abdominal surgery, when speed was a factor that had always to be reckoned with, and before the introduction of absorbable suture material, primary hernia was extremely rare. This was because the wounds were closed with heavy silk sutures. While the primary results, so far as hernia was concerned, were good, the late results were poor because of the low percentage of primary union that was obtained in those days. When, later, rapid operating became of less importance, more attention was given to closing the wound. With the introduction of absorbable suture material, closure by approximating layer to layer in proper anatomical relations was adopted. This, probably because of improved asepsis, gave a higher percentage of primary union, with less frequent occurrence of secondary hernia in cases clean at time of operation. In cases septic at time of operation, however, this method yielded a low percentage of primary union, very much lower than in clean cases. With the further improvements in technic of McBurney and Pfannenstiel, post-operative herniæ, both primary and secondary, have been practically abolished, and to-day the primary consideration in closing an abdominal incision made by either of these methods is to secure primary union, and thus avoid the prolonged convalescence that follows in the wake of an infected wound. In the case of the median-line abdominal incision, still so often employed, much greater care has to be used in suturing, both as regards the suture material and the method used, for in such a wound far greater strain is brought to bear upon the sutures uniting it. Just how often a median-line incision in the lower abdomen, closed with absorbable material, breaks open shortly after operation, it is difficult to say. Certainly the accident happens far more frequently than it should.

When an abdominal wound breaks open during a violent fit of post-operative vomiting, it is fair to presume that the sutures used to unite it were not strong enough. Likewise, when a low percentage of primary wound union obtaining with one suture material immediately yields to a high percentage when another material is employed, it is fair to presume that the first was at fault.

What, then, are the requirements we should strive to meet in closing

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\* Read before the Polyclinic Medical Society.

every abdominal incision? It seems to me that two are of paramount importance—prevention of hernia and the securing of primary union.

*Hernia.*—When this occurs shortly after the operation, it is always due to a sudden severe strain. Coughing and vomiting are the most frequent causes of such an accident. Investigation into these cases will usually show that the material employed was of insufficient strength, or had been weakened by premature absorption in the tissues. Catgut has probably been most at fault in this respect.

During the past year I have listened to reports of six cases where this accident occurred. In all, the wound had been closed with catgut, and without exception the secondary suturing was done with silkworm-gut. Secondary post-operative hernia, when not caused by defective technic in closing the wound, is due to infection of the wound. In this respect, it is interesting to hear the opinions of several surgeons of wide experience. Von Rosthorn writes: "During five years I practically saw no ventral hernia in my cases, except when suppuration had taken place." Bier: "I think it depends less upon the suture material used, and the so-called 'method,' than upon a satisfactory healing by first intention. If this does not succeed, then other measures fall short. I hardly ever remember seeing a post-operative hernia when healing by first intention has strictly occurred." Von Eiselsberg: "I have never found a hernia, provided that healing took place by first intention." Duhrssen: "When, however, an abscess occurs in the wound, a hernia follows, no matter how the wound was originally sutured."

It is of the greatest importance in closing abdominal wounds that the tissues should be left in their proper anatomical relations, and so retained, without undue tension or constriction, until permanent union has taken place. When infection occurs in a wound closed with absorbable suture material, these sutures become likewise infected, and slough out, releasing the tissues, so that secondary suturing is necessary if the patient is not to be left with a permanently weakened abdominal wall.

The abdominal incision differs from incisions in all other parts of the body in one very important point—and this is particularly true of the lower abdomen; it is frequently subjected to great increase in tension. This fact should always be taken into consideration when closing the wound, especially in closing one made in the median line, where the strong outward pull of the oblique and transversalis muscles causes an almost constant strain on the sutures. This strain is greatly increased when retching or vomiting occurs; therefore the necessity of suture material of known tensile strength that will not be weakened by premature absorption or infection before the fascia is firmly united.

Separation of the fascial edges, with a high percentage of post-operative hernia, is the rule in wound union by secondary intention. We often hear the remark, "It makes no difference how the wound is closed, provided primary union is obtained"; hence the necessity of a method of closing the incision that will give the highest percentage of primary union.



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During the past year I have listened to reports of six cases where this accident occurred. In all, the wound had been closed with catgut, and without exception the secondary suturing was done with silkworm-gut. Secondary post-operative hernia, when not caused by defective technic in closing the wound, is due to infection of the wound. In this respect, it is interesting to hear the opinions of several surgeons of wide experience. Von Rosthorn writes: "During five years I practically saw no ventral hernia in my cases, except when suppuration had taken place." Bier: "I think it depends less upon the suture material used, and the so-called 'method,' than upon a satisfactory healing by first intention. If this does not succeed, then other measures fall short. I hardly ever remember seeing a post-operative hernia when healing by first intention has strictly occurred." Von Eiselsberg: "I have never found a hernia, provided that healing took place by first intention." Duhrssen: "When, however, an abscess occurs in the wound, a hernia follows, no matter how the wound was originally sutured."

It is of the greatest importance in closing abdominal wounds that the tissues should be left in their proper anatomical relations, and so retained, without undue tension or constriction, until permanent union has taken place. When infection occurs in a wound closed with absorbable suture material, these sutures become likewise infected, and slough out, releasing the tissues, so that secondary suturing is necessary if the patient is not to be left with a permanently weakened abdominal wall.

The abdominal incision differs from incisions in all other parts of the body in one very important point—and this is particularly true of the lower abdomen; it is frequently subjected to great increase in tension. This fact should always be taken into consideration when closing the wound, especially in closing one made in the median line, where the strong outward pull of the oblique and transversalis muscles causes an almost constant strain on the sutures. This strain is greatly increased when retching or vomiting occurs; therefore the necessity of suture material of known tensile strength that will not be weakened by premature absorption or infection before the fascia is firmly united.

Separation of the fascial edges, with a high percentage of post-operative hernia, is the rule in wound union by secondary intention. We often hear the remark, "It makes no difference how the wound is closed, provided primary union is obtained"; hence the necessity of a method of closing the incision that will give the highest percentage of primary union.

Of the many features entering into the process of wound infection, two I believe to be of paramount importance; undue traumatism of the tissues at the time of operation, and the use of absorbable suture material in septic cases. Traumatism greatly lessens the vitality of the tissues and their power of resistance, while absorbable suture material introduces what I believe to be an excellent culture medium. Before absorption of the suture material can take place, it must be converted into a soluble gelatin. Gelatin is an excellent culture medium upon which bacteria readily grow. The tissues, when in a normal or approximately normal state, will readily take care of a small amount of infection if the wound has been closed with non-infectable suture material, and is free from areas of necrotic tissue. It is a different story, however, in a wound containing many areas of traumatized tissue, and where numerous foci of pressure necrosis of the tissues have been produced by the tying of strangulating sutures. Such a wound falls an easy prey to subsequent infection, as most anyone's clinical experience will show, and yields a very low percentage of primary union.

Halsted, in an excellent article on ligature and suture material recently published in the *Journal of the American Medical Association*, makes the following pertinent remark: "Catgut, even that which we have no cause to believe is not sterilized, irritates the wound for some reason, perhaps because it serves as culture medium for saprophytic organisms which are carried into it from the top epithelium and follicles of the skin. We have frequently observed this reaction, and have occasionally had an opportunity to compare the reaction caused by catgut with that of fine silk in wounds clinically studied in the same patient at the same time. Let the surgeon interested in making the comparison, when he has occasion to amputate both breasts for malignant disease, take a running subcuticular stitch on one side with catgut and on the other with fine silkworm, and observe the healing wounds from day to day; or when operating on two goitres employ catgut or platysma suture in the one case and very fine silk in the other. There is not only greater local reaction in the cases sewed with catgut, but in them the wounds will occasionally open at one or more points to discharge a few drops of clear or cloudy fluid."

This favorable difference is even more marked with silkworm-gut than with fine silk, and where silver wire is used no evidence of any local inflammatory reaction can be observed. Why, then, continue to produce in the wound conditions so liable to defeat the very object we should strive most to obtain? Prejudice has a great deal to do with this question. As a good illustration of this is an answer I once received from a prominent surgeon, to whom I put the question: "Why do you use absorbable suture material of unreliable strength and uncertain absorbability?" His reply was: "I use suture material that is absorbable because my patients object to the removal of nonabsorbable sutures more than they do to the operation itself." More, I wonder, than they do to the dangers of primary hernia or to a prolonged

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convalescence accompanying an infected granulating wound, with a possible secondary operation for hernia.

I do not believe that absorbable suture material should be used in the closure of the abdominal incision, for its unreliability is too great. In cases septic at time of operation, I feel certain it should never be used.

Only a short time ago, in discussing this point with a surgeon who had just finished reading a paper on a new method of wound closure with catgut, I called his attention to the fact that his cases showed only about 67 per cent. primary unions. "Oh," he replied, "but many of the cases in this series were suppurative processes, where it is always difficult to get primary union!" This seems to be a very current surgical belief; that it is a heresy I shall endeavor to show.

Some years ago I published my results with the use of catgut and with silk as a suture material in closing the abdominal incision. The results were as follows:

CATGUT	
Primary union in clean cases.....	70.5 per cent.
Primary union in septic cases.....	50.0 per cent.
Percentage of cases septic at time of operation.....	26.0 per cent.
Average primary union .....	60.2 per cent.

The catgut not only gave a low percentage of primary union in the clean cases, but in the suppurative processes actually yielded one infection for every two cases operated upon. I then abandoned this material and in the next series of cases used buried silk and silkworm-gut in the skin, with the following gratifying results:

Primary union in clean cases.....	91.2 per cent.
Primary union in septic cases.....	95.0 per cent.
Percentages of cases septic at time of operation.....	29.8 per cent.
Average primary union .....	93.1 per cent.

Since that time I have used a method which I described in the *Journal of the American Medical Association* in 1907, and with which the results have been so near perfection that I feel it worthy of a more extended report. The essential feature of this method, closure of the wound with nonabsorbable sutures fastened outside of the skin and subsequently withdrawn, I afterward learned was described by Doctor Haughey, of Battle Creek, some years before my article appeared, and to him I gladly acknowledge priority. We both used silkworm-gut, his being an over-and-over stitch shotted outside the wound, while mine was a continuous mattress stitch, the ends tied over gauze. The mattress stitch I found gave better approximation of the tissues, and could be more easily withdrawn. The long ends permitted a reopening of the wound when necessary without taking out the sutures.

This method will guard absolutely against tearing open of the wound, and will give a high percentage of primary unions. In the hands of a clean operator, it will give primary union just as often in the cases septic at time

of operation as in the clean cases. I now use a No. 23 silver wire introduced on a linen thread carrier in place of silkworm-gut.

*Technic.*—The closure of the wound is effected as follows:

*Peritoneum:* Where the opening is small, it is closed with a purse-string suture of fine silk or linen thread. This introduces a minimum amount of suture material, and turns the raw edges of the peritoneum outside of the abdominal cavity, preventing intestinal or omental adhesions. Longer incisions are closed with a continuous suture of silver wire brought out through the skin or a buried one of fine kangaroo tendon.

*Fascia:* Here a continuous mattress suture is used. The free ends are brought out through the skin, one inch from the angles of the wound, and fastened over a roll of gauze to the free ends of the subcuticular stitch uniting the skin.

*Fat:* When the fat is of extensive thickness, it is likewise brought together with a continuous suture, emerging at the angles of the wound.

*Skin:* A subcuticular suture brings the skin together. The free ends are brought out through the skin one inch from the angles of the incision and on the opposite side from the ends of the fascial stitch. A small roll of gauze is then laid over the wound, the sutures given a final tightening, and fastened, skin ends to fascial ends.

*Subsequent care:* On the second day the dressing is taken down and the roll of gauze cut in two so as to allow proper inspection of the wound. This should be examined every day or so that any effusion of serum or blood clots in the wound may be detected early and liberated before the formation of pus takes place. By this precaution wound infection from the suppuration of an unabsorbed effusion of blood-clot will often be avoided. The more or less common practice of not looking at the wound for nine or ten days, or until an elevation of temperature and pulse develops, is only too often responsible for cases of secondary union. When the elevation of temperature and pulse occurs, pus has formed and secondary union is inevitable.

If infection should occur in a wound closed by the above method, the sutures are unfastened and the skin one withdrawn to allow free drainage. Where the infection extends under the fascia, the fascial suture is not removed, but the edges of the fascia are separated upon it to allow proper cleansing. Later, when the infection has subsided and union begun, traction on the free ends of the suture brings the fascia together. As this suture is not tied in the fascia, it does not slough out, but gives perfect control of the fascial flaps until removed. Thus, firm union of the fascia in infected cases as well as in clean cases becomes possible without resort to secondary suturing. If the case is one of appendicitis, where drainage has been employed, the free ends of the sutures are left loose until the drain is removed, and are then tightened.

By this method many indications are met. Halsted, in the article above referred to, speaking of faulty technic, says, "One should not bring parts together in such degree of tension as to cause necrosis, or interfere greatly



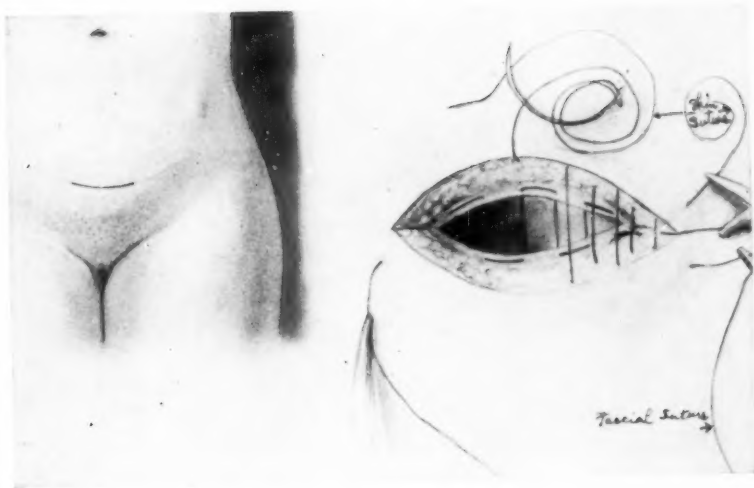
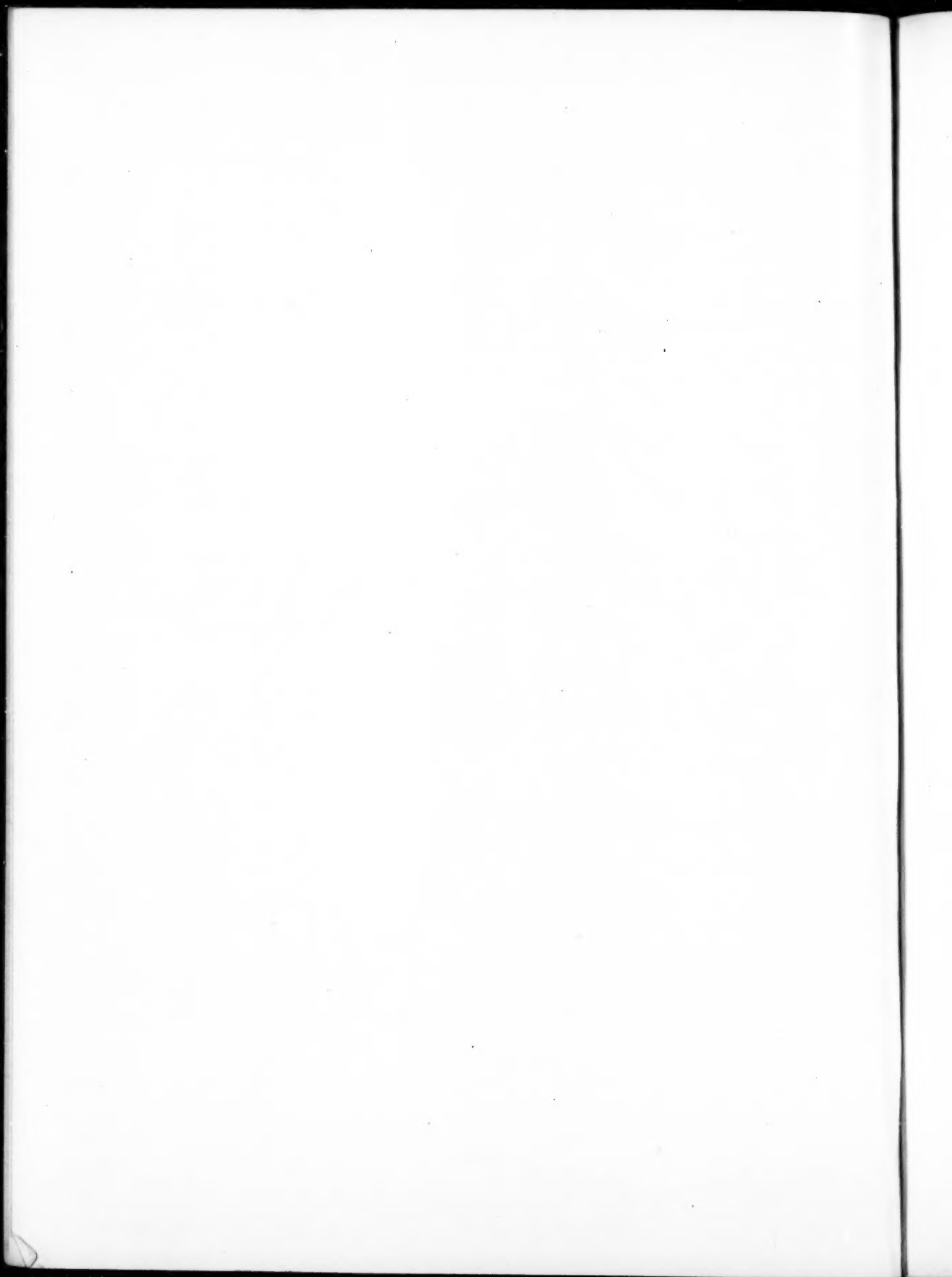


FIG. 1.



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with the blood supply, for nothing is gained by so doing, and decided harm may result." To this I heartily subscribe. Every ligature or suture tied in the wound, if tied tight enough to accomplish its purpose, includes in its bite a portion of devitalized tissue, the centre of an area of pressure necrosis, a foreign body, a menace to wound union; therefore, with the above method, we tie no sutures in the wound. The ends of the sutures are brought out through the skin and fastened over a bolster of gauze outside of the wound. This method snugly approximates the tissues, but does not impair their nutrition or in any way interfere with their circulation. Furthermore, if at any subsequent time we desire to liberate the tissues temporarily it is only necessary to release the outside fastenings.

I have spoken of the advisability of this in infected wounds, and would further call attention to its value in reopening the abdomen where secondary hemorrhage may have occurred.

In one of my cases, where this accident happened, the wound was reopened, the hemorrhage controlled, and the wound reclosed without the removal or re-introduction of a single suture.

Doctor Halsted further says: "For sewing up an abdominal wound, where it is necessary here and there to take heavy top stitches, perforating skin and muscles, silver wire serves admirably; when the section can be approximated without tension, we usually employ unrepeat perforating stitches of very fine silk. If the skin edges have to be brought together under considerable tension we recommend a subcuticular stitch of silver wire."

Seldom, if ever, in my experience have I found it necessary to take such deep mass sutures, and I notice with many operators a custom of reinforcing their abdominal wounds with such sutures, either of heavy wire or of silk-worm-gut. Some place as many as four or five of these through-and-through sutures in addition to continuous or interrupted sutures of catgut in the muscles, fascia and skin.

This certainly is a complicated and time-consuming procedure. Of the tissues held by the through-and-through nonabsorbable sutures, the fascia is the only one of importance, and this, in the method I have described, is held in closer and better approximation with one suture than is possible with numerous interrupted sutures enclosing the skin and muscles as well.

This "three-suture" method, which is also a "three-layer" method, appeals to me greatly, and the results obtained with it in a large number of cases have been most satisfactory. In the last 100 cases on the Gynecological Division, where it was used, the percentage of primary union was 95 and the percentage of cases septic at time of operation 17. In the five cases that failed to unite by primary union, the colon bacillus was responsible for two, a retained blot-clot for two, and in the other a slight skin infection (the patient removed the dressing on the second day after operation, and tried to take the sutures out).

## A COMPOSITE STUDY OF THE HYPOGASTRIC ARTERY AND ITS BRANCHES

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THE blood vascular tree has at all times been a particularly interesting phase of anatomical study. Its influence on the development of the individual, its practical importance in medicine, and the necessity for the surgeon to thoroughly orient himself with it give additional stimuli to further our knowledge concerning it.

Bader in 1866, Krause in 1868, and Ruge in 1883 commented upon the regularity and frequency of arterial variations and suggested grouping these variations into anatomic types. This phase of anatomical study, the establishment of anatomic types, aims to generalize the variations of the large arterial trunks of the body, to arrange them into a form more easily comprehended and retained and, if possible, to clear the unbelievable confusion and chaos that exist in the literature on arterial variations.

The observation and classification of the branches of any one of the large arterial trunks, in a sufficiently extensive series of cadavers, disclose the fact that variations of the blood-vascular tree fall naturally into distinct types. This conclusion is supported by the studies of Hitzrot on the axillary, Bean on the subclavian, and those of the writer on the femoral and coeliac axis arteries. Mention is made in the studies of the femoral and coeliac axis arteries of the occurrence of numerous minor arterial variations not entirely in accord with the described and classified types, yet the arteries observed allow of a distinct grouping into definite and well defined types. Analogous results are found in the present study of the hypogastric (internal iliac) artery.

This paper, the third of the blood-vascular tree studies, presents a composite study of the hypogastric (internal iliac) artery, and is based on records and observations made from student and personal dissections at the Daniel Baugh Institute of Anatomy of the Jefferson Medical College. Dissections of 93 cadavers were recorded: 72 male white, 11 female white, 7 male negro, and 3 female negro. There were 91 dissections of the hypogastric artery on the right side of the body and 90 dissections on the left side, making 181 dissections in all.

Section A of this paper presents observations on the point of bifurcation of the aorta, and the length and point of bifurcation of the common iliac and hypogastric (internal iliac) arteries. Section B contains a description of

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the types of hypogastric artery. Section C embraces a description of the individual branches of the hypogastric artery. Section D summarizes and discusses the results of the present study.

### SECTION A

In the course of the observations on the hypogastric artery, the point of division of the abdominal aorta was found as follows:

	Per cent.
Opposite the	
Third lumbar vertebra.....	4
Intervertebral disc between the third and fourth lumbar vertebræ..	9
Fourth lumbar vertebra.....	59
Intervertebral disc between the fourth and fifth lumbar vertebræ..	20
Fifth lumbar vertebra.....	8

Schwalbe and Pfitzner found the division of the aorta opposite the top of the fifth lumbar vertebra in 20 per cent. of their cases, and opposite some part of the fourth lumbar in 73.3 per cent.

Quain and Dwight report the following observations:

	Quain Per cent.	Dwight Per cent.
Opposite third lumbar .....	3	2.8
Between cartilage of the third and fourth lumbar vertebræ	6	3.5
Opposite fourth lumbar .....	62	76
Between cartilage of the fourth and fifth lumbar vertebræ	14	5
Opposite fifth lumbar vertebra.....	11	11.5

*Arteria Iliac Communis.*—The length of this artery presents considerable variation: Rauber gives its length as 4 to 6 cm.; Henle 2 to 8 cm. Sappey gives its normal length as 6 cm. Quain's observations vary from 2.5 to 10.1 cm.

The author's observations as to the point of division and length of the common iliac artery in 181 dissections are as follows:

	Number of arteries	Per cent.
Opposite fifth lumbar vertebra.....	24	14.5
Between fifth lumbar vertebra and superior margin of sacrum .....	120	85.5
Length of common iliac artery:		
2.5-4 cm. ....	29	15.2
4.0-5 cm. ....	59	36.0
5.0-6 cm. ....	52	27.2
6.0-7 cm. ....	11	5.8
7.0-8 cm. ....	19	10.0
8.0-9 cm. ....	10	5.2

There is a well marked tendency for the left common iliac artery to bifurcate at a lower level than the right. When the common iliac is more



than 6 cm. in length it is more or less tortuous in its course, and Thompson states that the length of the common iliac is somewhat greater in females and that the tendency in females is to bifurcate at a lower level. The number of females in this series is too small to make similar comparisons.

The length of the hypogastric artery varies considerably. Quain gives the average length of 2.5 to 4 cm.; Poirier, 2 to 4 cm. The observations in 181 dissections are as follows:

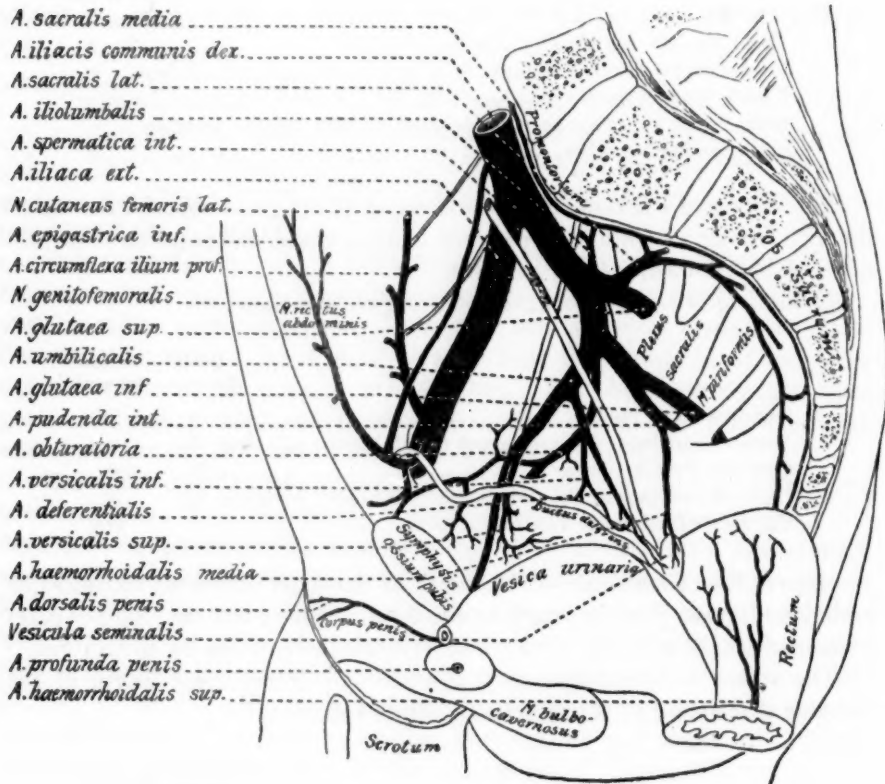


FIG. 1.—Type I occurs in 40 per cent. of the arteries studied.

	Number of arteries	Per cent.
1.5-2.5 cm. ....	24	13.5
2.5-3.5 cm. ....	50	28.0
3.5-4.5 cm. ....	67	37.6
4.5-5.5 cm. ....	20	11.2
5.5-6.7 cm. ....	17	9.5

It is worthy of note that if the aorta divides at a lower level, there is no shortening of the iliac or hypogastric arteries, the division of the latter vessels occurring at lower levels.

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### SECTION B—DESCRIPTION OF TYPES

**TYPE I.**—This type (Fig. 1) occurs in 40 per cent. of the cadavers studied, 24 per cent. on the right side of the body, and 16 per cent. on the left side. In this group the superior gluteal artery constitutes the largest branch and arises as the dorsal or posterior trunk of the hypogastric (internal iliac) artery; the internal pudendal (internal pudic) and the inferior gluteal arteries arise in a common trunk caudal to the superior gluteal.

The obturator, vesical, middle hemorrhoidal, and uterine arteries arise as separate branches from the caudal continuation of the hypogastric artery. The obturator

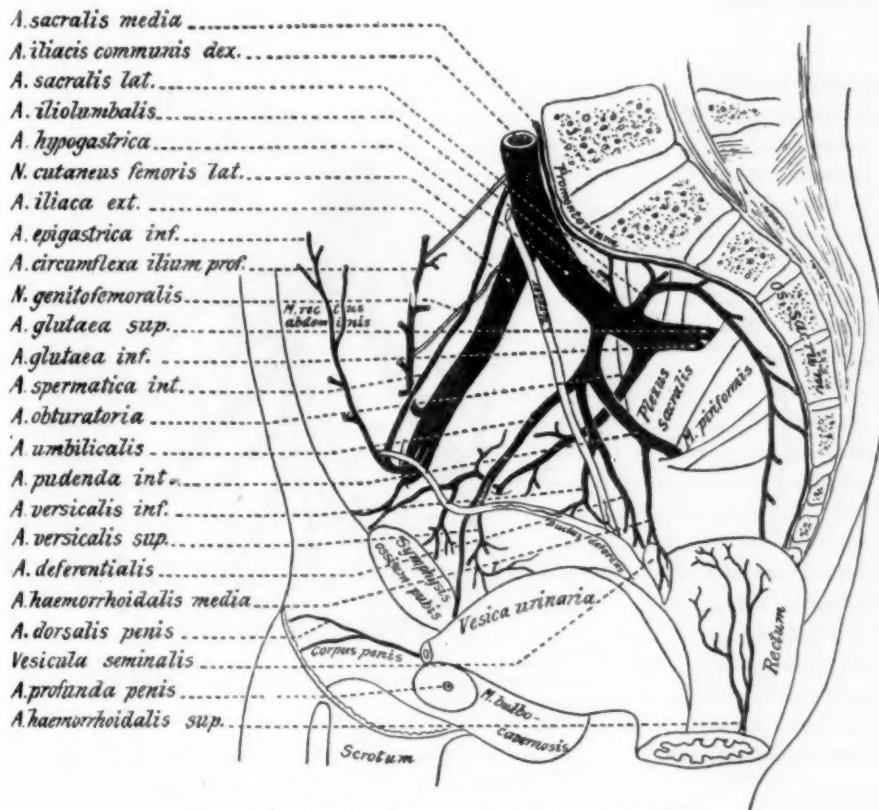


FIG. 2.—Type II is found in 24 per cent. of the arteries studied.

artery in 45 per cent. of the vessels of this group arises in a common trunk with the inferior (deep) epigastric artery from the external iliac.

The obturator artery arises 16 times as a separate branch from the superior gluteal artery. In one subject of this group the obturator is present as a branch of the femoral artery.

There are in this type 28 male white, 6 female white, 3 male negro, 1 female negro subjects. Jastschinski found this type present in 38 per cent. of the subjects classified, 20 per cent. on the right side of the body and 18 per cent. on the left side.

**TYPE II.**—This type (Fig. 2) occurs with slight variations in 24 per cent. of the vessels observed, 14 per cent. on the right side of the body, and 10 per cent. on the left side. The superior and inferior gluteal arteries arise from the hypogastric

(internal iliac) artery in a common trunk. The internal pudendal, obturator, and uterine arteries arise as separate branches from the caudal continuation of the hypogastric artery.

In 40 per cent. of the arteries of this group, the obturator artery arises as a separate branch from the common trunk of the superior and inferior gluteal arteries. The obturator artery occurs three times in this group in a common trunk with the inferior (deep) epigastric, which common trunk arises from the external iliac artery. In every case observed the common trunk for the superior and inferior gluteal arteries makes its exit from the pelvis by passing through the great sacrosciatic foramen (foramen ischiadicum majus) cephalic to the piriformis muscle (foramen suprapiriforme).

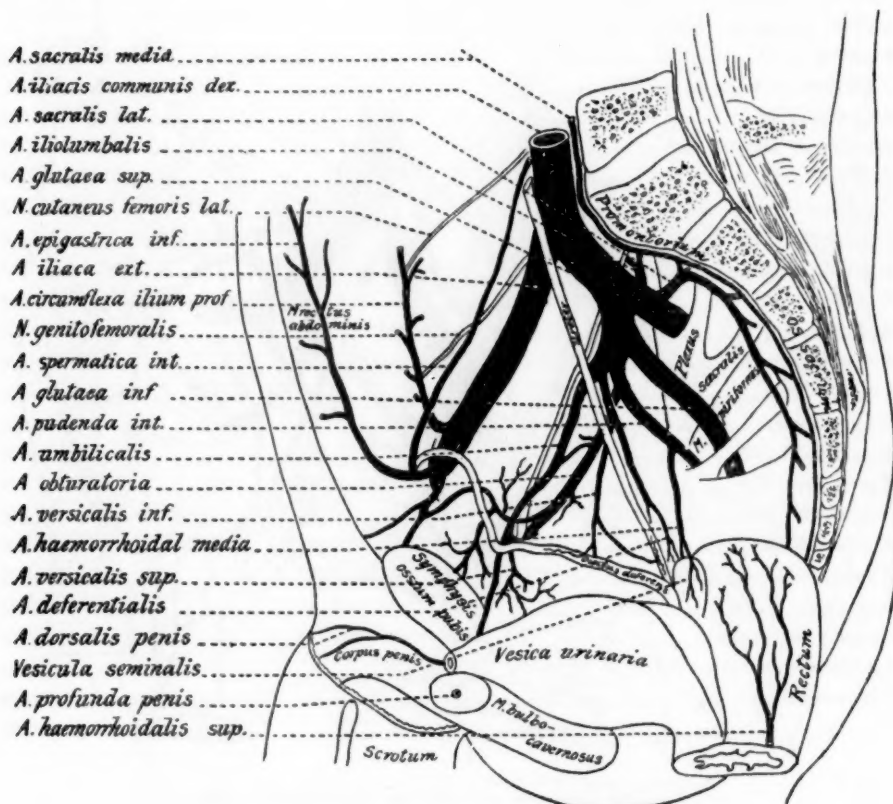


FIG. 3.—Type III occurs in 17 per cent. of the arteries studied.

The internal pudendal artery in two subjects of this group is present as a separate branch of the common trunk for the superior and inferior gluteal arteries after the trunk has made its exit from the pelvis.

There are in this type 22 subjects in all, 16 male white, 3 female white, 2 male negro, and 1 female negro.

TYPE III.—This type (Fig. 3) is found with slight variations in 17 per cent. of the arteries classified, 10 per cent. on the left side of the body and 7 per cent. on the right side. In this type the superior gluteal, inferior gluteal, and internal pudendal arteries occur as separate branches of the hypogastric artery. The obturator in this group is variable in its origin, occurring 17 times as a separate branch of the hypo-

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gastric artery, 4 times as a branch of the inferior gluteal, 5 times as a branch of the internal pudendal, 4 times in a trunk common with the inferior (deep) epigastric, and in two cases it is present as a branch of a large middle hemorrhoidal artery.

There are in this type 16 subjects in all, 14 male white, 1 female white, and 1 male negro.

TYPE IV.—This type (Fig. 4) is found in 11 per cent. of the arteries observed, 3 per cent. on the right side of the body and 8 per cent. on the left side. In this group the obturator, the internal pudendal, and the inferior gluteal arteries arise from the hypogastric artery in a common trunk. The superior gluteal artery arises as a sepa-

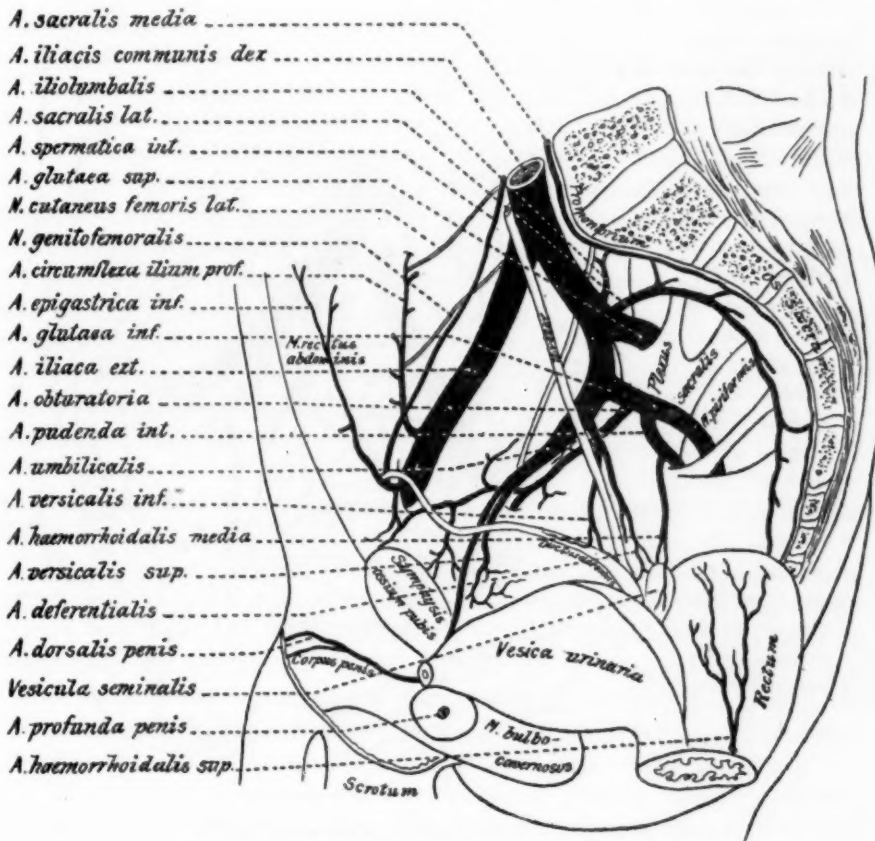


FIG. 4.—Type IV occurs in 11 per cent. of the arteries studied.

rate branch dorsal to the trunk for the inferior gluteal, obturator, and internal pudendal arteries.

The superior gluteal artery is usually larger than the trunk for the inferior gluteal, obturator and internal pudendal arteries. There are in this type 11 subjects in all, 8 male white, 1 female white, 1 male negro, and 1 female negro.

TYPE V.—This type (Fig. 5) occurs in 7 per cent. of the arteries observed, 2 per cent. on the right side of the body and 5 per cent. on the left side. In this group the superior gluteal, inferior gluteal, obturator and internal pudendal arteries arise from the hypogastric artery in a common trunk. It is interesting to note in this connection that this group is represented wholly by male whites, 6 in all.

## SECTION C—DESCRIPTION OF BRANCHES

*A. obturatoria*: Probably no artery in the human body of proportionate size has so voluminous a literature as the obturator artery. It has been the subject of repeated anatomical research. Haller, in 1745, first observed and noted the origin of the obturator artery as a branch of the inferior epigastric. Murray and Portal recorded instances in which this vessel arises variously as a branch of the external iliac, femoral and inferior epigastric arteries. Monroe in 1805, Cooper in 1807, and Barclay in 1806 noted

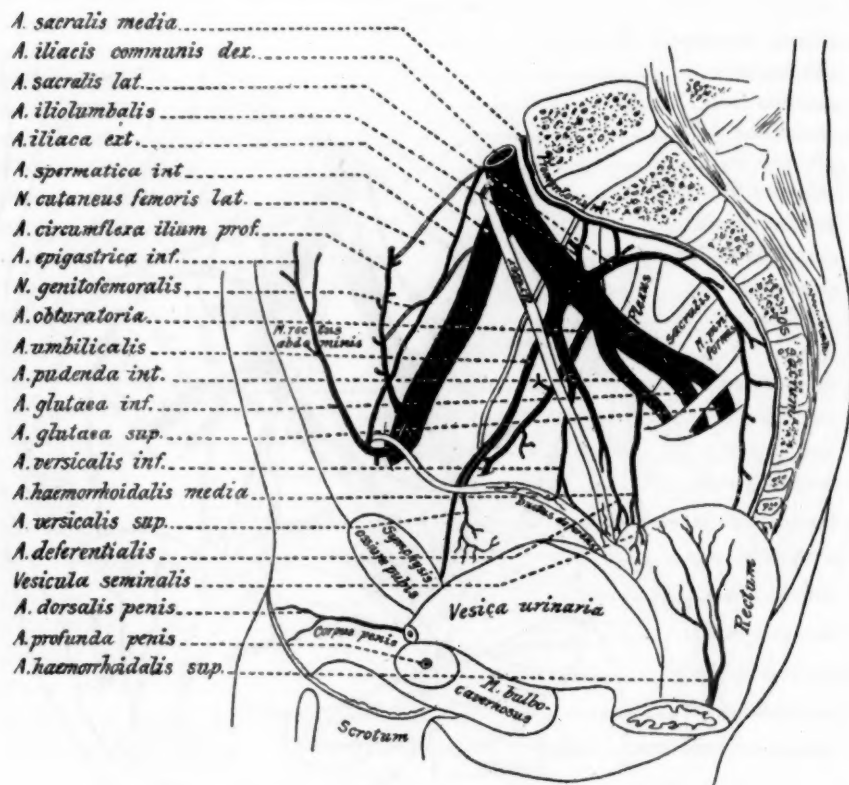


FIG. 5.—Type V occurs in 7 per cent. of the arteries studied.

anomalous obturator vessels coursing in relation to the free edge of the lacunar (Gimbernat's) ligament and their importance to femoral hernia.

The obturator artery presents considerable variation in its origin, size and distribution. It arises in a trunk common with the inferior epigastric in 19.3 per cent. of the cadavers studied. This variation occurs in 12 per cent. of the cadavers on the right side of the body, and in approximately 7 per cent. on the left side, and in 30 per cent. on both sides of the same body. The important statistics in literature as to the frequency of this variation are stated in the following table:



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	Number of bodies examined	Per cent.
Quain .....	400	31.9
Brochet .....	63	..
Cloquet .....	500	31.4
Hoffman .....	63	32.5
Pfitzner .....	307	37.6
Hesselbach .....	64	42.2
Krusche .....	63	21.2
Dwight .....	500	25.8
Jastschinski .....	404	24
Levi .....	100	25.2

The obturator artery arises 16 times (9 per cent.) as a separate branch of the superior gluteal artery; 5 times (3.5 per cent.) as a branch of the inferior gluteal; 7 times (4 per cent.) as a branch of the pudendal artery. The obturator artery arises 17 times (9.4 per cent.) as a separate branch from the common trunk for the superior and inferior gluteal arteries. In 10 per cent. of the subjects observed, this vessel is found in a common trunk with the superior and inferior gluteal arteries and in 7 per cent. in a common trunk with the superior gluteal, inferior gluteal, and internal pudendal arteries. It arises three times as a branch of the external iliac artery caudal to the origin of the inferior epigastric.

In two cases observed, it occurs as a branch of the femoral artery. Mention is made by the writer in the study of the femoral artery of the occurrence in two subjects of the obturator artery arising in a common trunk with the medial circumflex and inferior epigastric arteries, which trunk takes origin from the external iliac. This unusual variation was not observed in this series.

The obturator arises in two stems which unite to form a single obturator artery in 11 of the cases observed. In six of the subjects of the latter group, one stem takes origin from the inferior epigastric artery and the other from the hypogastric artery. The obturator occurs three times as a twin vessel, both rami remaining independent. Jastschinski in study of 88 fetuses states that the inferior epigastric artery rarely arises in two stems, and that the additional vessel is in reality another obturator artery.

The common trunk for the obturator and inferior epigastric arteries varies in length from 1 to 3 cm. The common origin of the obturator and the inferior epigastric is of importance since, in its course through the pelvis to the obturator canal, it is in close relation with the femoral (crural) ring (annulus femoralis). The femoral ring is above the inner opening of the obturator canal.

The relation of the obturator artery to the femoral ring varies as follows:

1. If it arises from the external iliac artery it bears little or no relation to the femoral region.
2. If it arises from the femoral artery it usually courses between the femoral vein and the lacunar (Gimbernat's) ligament, usually dorsal and caudal to the femoral ring. In about one-half of the recorded cases in

literature the obturator artery courses along the outer half or two-thirds of the femoral ring, in the latter position it is most likely to be injured and result in dangerous hemorrhage. To avoid this injury the iliopubic ligament should be incised as near as possible to the lacunar ligament.

3. If it arises as a common trunk with the inferior epigastric, the relation of the obturator to the femoral ring varies—(a) if from the central portion of the artery between the external iliac artery and the inguinal ligament, or from the summit of the common trunk of the inferior epigastric and obturator arteries, it pursues an arched course and is usually related to the lateral border of the femoral ring; (b) if it arises at or above the inguinal ligament, it lies at the medial border or middle of the femoral ring. It is usually related to the lateral side of a femoral hernia. The obturator artery courses transversely across the hernia according to Jastschinski in 22 per cent. of the cases. The writer observed two cases in which the obturator artery courses transversely across the annulus femoralis. In female subjects the obturator artery courses more frequently along the lateral border of the femoral ring than the medial.

The ramus pubicus superior usually occurs as a branch of the inferior (deep) epigastric artery. Not infrequently this vessel arises from the inferior epigastric at the medial border of the femoral ring and frequently is of large calibre and easily injured in operative procedures, becoming a source of troublesome and dangerous hemorrhage. The obturator artery leaves the obturator canal and usually divides into two diverging branches, both of which course on the pelvic (ental) side of the obturator membrane between the latter and the obturator externus muscle. The ventral branch lies on the bone, the dorsal branch lies on the ectal surface of the obturator membrane. The ventral branch gives off a large number of small rami, some of which supply the obturator internus muscle. The obturator artery usually pierces the obturator canal and divides into two terminal branches, ramus anterior and posterior. The ramus anterior sends a branch to the symphysis pubis and then courses along the inferior ramus of the pubis. The ramus posterior usually gives off three branches; the ramus acetabular, the ramus internus to the medial surface of the obturator membrane, and the ramus externus which supplies the ischial nutrient arteries.

*Arteria prostatica:* This vessel varies in its course, origin and distribution. It arises in 10 per cent. of the cadavers observed as a branch of the middle hemorrhoidal, 5 times as a branch of the inferior gluteal, 15 times as a branch of the obturator, 10 times as a branch of the ischiopudendal trunk, and 30 times as a branch of the anterior trunk of the hypogastric artery after its division. It is also not infrequently present as a branch of the umbilical artery. Occasionally it arises in a common trunk with the inferior vesicle artery. The direction of the prostatic artery varies in accordance with its origin. The usual course is caudal, medial and ventral. The consideration of the prostatic artery as the trunk of origin for the profunda and dorsalis penis arteries will be described subsequently.

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*Arteria vaginalis*: This vessel is the homologue of the prostatic artery in the male. It is frequently confused with the inferior vesicle artery. The vaginal artery is represented as a twin vessel in 40 per cent. of the female subjects of this series. This vessel may occur as a branch of (a) the inferior gluteal, (b) the ischiopudendal trunk, (c) the obturator, (d) the anterior trunk of the hypogastric and uterine arteries. The vaginal artery arises in two subjects in a common trunk with the middle hemorrhoidal.

In those subjects in which the vaginal is represented as a double vessel, the proximal artery is found either as a branch of the anterior trunk of the hypogastric, uterine or internal pudendal, the distal artery either from the internal pudendal, ischiopudendal trunk, obturator, inferior gluteal or in a common trunk with the middle hemorrhoidal.

The vaginal artery is distributed to the lateral surface of the vagina, the posterior surface being vascularized by the middle hemorrhoidal artery.

*A. glutea inferior (A. ischiadica)*: This vessel presents considerable variation in its course, origin and distribution.

The committee on collected statistics and investigations, in an observation of 50 cases, state that this vessel arises in 75 per cent. of the arteries recorded from the anterior trunk of the hypogastric artery, in 21.4 per cent. as a branch of the superior gluteal artery.

Cruveilhier and Sappey describe the inferior gluteal as arising either in a common trunk with the superior gluteal or internal pudendal arteries.

The inferior gluteal artery arises in a common trunk with the internal pudendal artery in 40 per cent. of the cases classified. The length of the ischiopudendal trunk varies from 2 to 8 cm. In 25 per cent. of the subjects in which this arterial trunk is present, it is from 6-8 cm. and divides into the internal pudendal and inferior gluteal arteries after its exit from the pelvis. This division occurs at or close to the sacrotuberous ligament under cover of, or at the lower margin of, the piriformis muscle, and at times 2-4 cm. caudal to the piriformis muscle. In approximately 30 per cent. of the subjects, the ischiopudendal trunk is from 0.02-2.5 cm. in length. The ischiopudendal trunk usually divides into the internal pudendal and inferior gluteal arteries in the pelvis; the internal pudendal artery occasionally arising from the ischiopudendal trunk within 1 cm. of the lateral margin of the sacrotuberous ligament. The inferior gluteal frequently takes a circuitous course at first medial to the internal pudendal artery, then crosses the latter vessel and has a position lateral to the (Fig. 6) internal pudendal artery and medial to the sciatic nerve.

The inferior gluteal artery arises, in 24 per cent. of the cadavers studied, in a common trunk with the superior gluteal artery. The inferior gluteal artery in these cases usually leaves the pelvis through the suprapiriforme, and is given off by the common trunk for the superior and inferior gluteal arteries at or just below the cephalic border of the piriformis muscle. Less frequently the inferior gluteal artery takes origin from the common trunk of the superior and inferior gluteal arteries, either in the pelvis or under cover

of the upper fibres of the piriformis muscle, leaving the pelvis through the foramen infrapiriforme. The inferior gluteal artery in 17 per cent. of the subjects studied is present as a separate branch of the anterior trunk of the hypogastric artery. In 10 per cent. of the subjects studied, it occurs in a common trunk with the internal pudendal and obturator arteries. In 7 per cent. of the subjects studied the inferior gluteal artery is found in a common trunk with the superior gluteal, obturator and internal pudendal arteries.

The inferior gluteal artery is represented by two vessels, each having a separate origin in 16 per cent. of the arteries observed; both inferior gluteal arteries arise from the ischiopudendal trunk ten times. One inferior gluteal

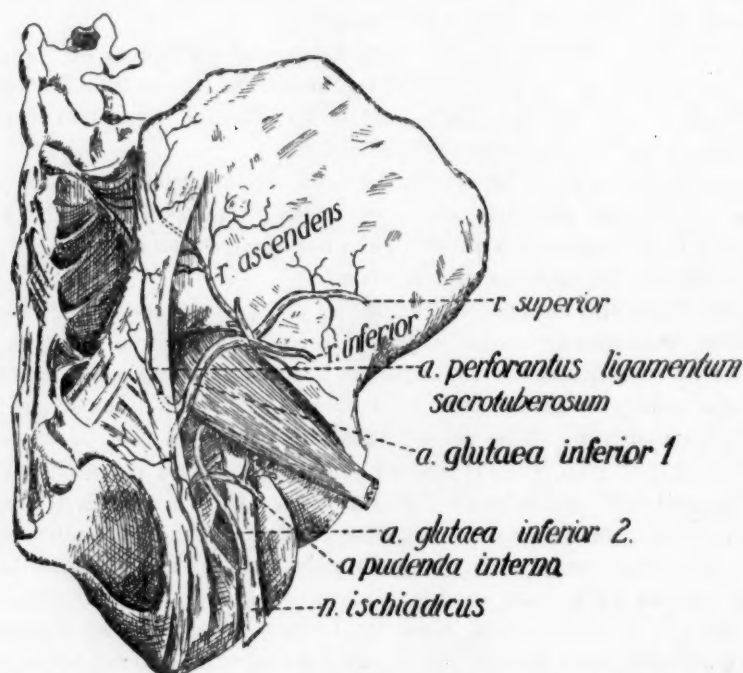


FIG. 6.—Type VI illustrates the occurrence of the inferior gluteal artery as a twin vessel. It also illustrates the usual relations of the sciatic nerve, inferior gluteal artery and internal pudendal artery.

artery arises as a branch of the anterior trunk of the hypogastric artery or in a common trunk with the internal pudendal, the other as a branch of the superior gluteal twelve times (Fig. 6). Both inferior gluteal arteries arise from the superior gluteal in nine of the cases. In three of the subjects studied, one inferior gluteal artery is present as a branch of the ischiopudendal trunk, the other as a branch of the obturator artery.

The inferior gluteal is usually dorsal, cephalic and medial to the internal pudendal artery in the pelvis.

Poirier describes four terminal branches: (a) R. posterior internus, (b) R. posterior externus, (c) R. inferior externus, (d) R. inferior internus,



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which is the dorsal and caudal continuation of the main stem of the artery. I have used the nomenclature of Poirier in the description of the terminal branches of the inferior gluteal artery.

The inferior gluteal artery is at times the trunk of origin of the obturator, middle hemorrhoidal, prostatic and vaginal arteries. The extrapelvic are, however, the more conspicuous branches of this vessel.

*Ramus posterior internus (Arteria perforans ligamentum sacrotuberosum)*: This vessel is usually well marked and of large calibre. It arises under cover of the piriformis muscle, courses medially and cephalically between the fibrous planes of the sacrotuberous ligament and here redivides and arborizes and occasionally reaches the sacrum. The branches perforate the sacrotuberous ligament and terminate either in the ligament or in the gluteus maximus muscle.

The number of arteries to the sacrotuberous ligament varies from 1 to 4 and the point of origin is variable. In 19 per cent. of the cases it arises at the caudal margin of the piriformis, close to the lateral margin of the sacrotuberous ligament. It frequently divides before it enters the fibrous planes of the ligament. When the perforating arteries are 3 to 4 in number they enter the ligament immediately cephalic to the spine of the ischium.

In those subjects in which the inferior gluteal is represented as a double vessel, one of the latter usually becomes the A. perforans ligamentum sacrotuberosum. The perforating artery also occurs as a separate branch of the hypogastric artery or in a common trunk with the internal pudendal artery. It is also found as a branch of the obturator or superior gluteal arteries.

*Ramus posterior externus*: This vessel is not constant and presents considerable variation in its point of origin and number. It arises frequently from 2 to 4 cm. from the caudal margin of the piriformis muscle. The vessel gives branches to the gluteus maximus, piriformis, gemelli, and quadratus femoris muscles.

*Ramus inferior internus*: This is not infrequently a well marked vessel. As it descends between the gluteus maximus and tuberosity of the ischium it divides into 2 to 4 branches, terminating close to the caudal margin of the gluteus maximus muscle.

*Ramus inferior externus*: This vessel is of larger calibre than the R. inferior internus and is the caudal continuation of the inferior gluteal artery. It is usually medial to the posterior femoral cutaneous (lesser sciatic) nerve or between the posterior femoral cutaneous and the ischiadic (great sciatic) nerves. This vessel not infrequently pierces the sciatic nerve, separates its fibres and becomes ensheathed by the fascia covering the nerve. In its course it gives rami to the quadratus femoris, gemelli, and adductor magnus muscles. The A. comitans nervi ischiadici is essentially this vessel, or the latter occurs as a descending branch. In very rare instances the A. comitans nervi ischiadici is an artery of large calibre and is the principal vessel of the thigh, retaining its connection with the popliteal



artery. This anomaly is described by the writer in the study of the femoral artery.

*Arteria iliolumbalis:* Cruveilhier considers this vessel as a branch of the hypogastric artery, although frequently arising from the superior gluteal, as stated by Theile and Henle. This vessel is found in 38 per cent. of the cases studied as a branch of the superior gluteal and in 52 per cent. as a separate branch from the hypogastric artery. The distance between the origin of the iliolumbar artery and the origin of the superior gluteal is variable, in 60 per cent. of the subjects it is 1 to 1.5 cm., in the remaining subjects it varies from 1.5 to 3 cm., the latter distance is found only 6 times.

The iliolumbar artery occurs 3 times as a separate branch of the anterior trunk of the hypogastric artery; 4 times as a branch of the common iliac artery, and in 2 cases as a branch of the external iliac artery. It also arises 6 times from the hypogastric artery in a common trunk with the lateral sacral. It is found absent in 5 subjects, and in these cases it is replaced by the fourth lumbar. An additional small lumbar artery is found 18 times.

The iliolumbar artery usually divides into its terminal branches from 1 to 2.5 cm. from its origin. It usually divides into two terminal branches, less frequently into three—the ramus lumbalis or ascending branch and the ramus iliacus or transverse branch. The ramus lumbalis and ramus iliacus arise as separate branches in 18 per cent. of the cases observed.

*Arteria sacralis lateralis:* These vessels vary in calibre, number and distribution. There are usually two lateral sacral arteries on each side of the body. In 51 per cent. of the cases classified, the sacral arteries arise in a common trunk. In 10 per cent. of the arteries studied three sacral arteries are observed; the additional vessel usually enters the second sacral foramen as a separate branch. The superior lateral sacral artery gives origin to the spinal branch, which enters the first sacral foramen; the inferior lateral sacral artery gives origin to the spinal branches which enter the second, third and fourth sacral foramina.

In those subjects in which the lateral sacral arteries are found to arise in a common trunk, the latter single trunk arises in 88 per cent. of the subjects from the superior gluteal artery and in 12 per cent. from the hypogastric artery. Its origin is always caudal to the origin of the iliolumbar artery. The lateral sacral arteries arise six times in a trunk common with the iliolumbar.

*Arteria glutea superior:* Cruveilhier and Theile describe this vessel as representing the direct continuation of the hypogastric artery. This vessel is the largest branch of the hypogastric artery. Its calibre is usually larger than the combined calibre of all the other branches of the hypogastric artery. The superior gluteal artery arises in 24 per cent. of the subjects studied in a common trunk with the inferior gluteal artery. The obturator artery arises sixteen times as a branch of the superior gluteal. In 7 per cent. of the cadavers studied, the superior gluteal artery arises in a common stem with the obturator, internal pudendal and inferior gluteal (sciatic) arteries. The

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iliolumbar artery in 31 per cent. of the vessels observed occurs as a separate branch arising from the superior gluteal. The stem of the superior gluteal gives origin to lateral sacral arteries in 88 per cent. of the cases classified.

The superior gluteal artery in 80 per cent. of the subjects observed passes outward between the lumbosacral trunk and the first sacral nerve. In the remaining subjects it courses lateralward and somewhat caudalward to the lumbosacral trunk. This vessel makes its exit from the pelvis through the great sacrosciatic foramen (foramen ischiadicum majus) cephalic to the piriformis muscle (foramen suprapyriforme).

As it passes above the piriformis muscle it is rarely of any length, never more than 1 cm., and divides immediately at its emergence into 2 to 4 large arborescent branches. In 10 per cent. of the subjects observed, it divides into 5 or 6 terminal rami.

The ramus superior of the superior gluteal artery usually ascends and divides into numerous smaller rami between the gluteus medius and the maximus, and the ramus inferior, the descending or deep branch, is constant and lies between the gluteus minimus and medius muscles. This branch divides again into transverse, lateral, and descending branches. The inferior ramus arises as a separate branch from the ramus superior in 16 per cent. of the cases classified.

*Arteria pudenda interna:* This vessel presents considerable variation in its origin, distribution and branches. It arises in 40 per cent. of the subjects observed in a common stem with the inferior gluteal artery; in 24 per cent. as a separate branch of anterior trunk of the hypogastric artery; in 17 per cent. in a common trunk with the obturator and inferior gluteal arteries, and in 7 per cent. in a common trunk with the superior gluteal, inferior gluteal, and obturator arteries. The internal pudendal artery is found in two subjects as a separate branch of the common trunk for the superior and inferior gluteal arteries after the common trunk has made its exit from the pelvis through the foramen suprapyriforme. The internal pudendal artery occurs four times as a branch of the middle hemorrhoidal and in two cases as a branch of the uterine artery. The internal pudendal artery usually has an intrapelvic course of 4 cm. The consideration of the branches of the internal pudendal arteries and their variations follows:

(a) *The arteria hemorrhoidalis inferior* (1 to 3 in number) pierces the obturator fascia and courses medially into the fat of the ischiorectal fossa. Cerf states that the terminal branches of the inferior hemorrhoidal arteries go to the cutis ani and to the portion of the rectum caudal to the levator and sphincter ani muscles. It vascularizes the external sphincter ani and the skin only.

The levator ani muscle is vascularized by separate branches which arise from either the inferior hemorrhoidal or from the internal pudendal under cover of the levator ani muscle. They are smaller than the hemorrhoidal vessels, meet the parietal wall of the rectum, enter the submucosa, ascend,

and at times anastomose with the superior hemorrhoidal arteries. This affirms the work of Waldeyer.

The inferior hemorrhoidal arteries occasionally take origin as branches from the inferior gluteal. When only one inferior hemorrhoidal artery is present it arises under the spine of the ischium. The second hemorrhoidal arises in 22 per cent. of the subjects from the perineal branch of the internal pudendal; arising from the latter vessel near its origin or in the perineum.

The artery to the obturator internus muscle arises as a separate branch from the internal pudendal or in a common trunk with the inferior hemorrhoidal. It anastomoses with the obturator or with the intrapelvic branches of the internal pudendal.

In the further description of the branches of the internal pudendal artery, the writer presents the latter vessel as dividing in the perineum into two terminal branches: (a) perineal artery (superficial perineal), so called because it courses through the superficial perineal interspace; (b) the deep perineal, which vessel courses through the deep perineal interspace between the layers of the triangular ligament, and in this part of its course gives origin to the urethral and bulbar arteries. The deep perineal artery continues forward and divides into two terminal branches: (a) *A. profunda penis* (artery to the corpus cavernosum) and (b) the *A. dorsalis penis* which reaches the dorsum of the penis by piercing the superficial layers of the triangular ligament.

(b) *Arteria perinei* (superficial perineal): This vessel usually arises caudal to the inferior hemorrhoidal. In 28 of the cases observed it is the terminal branch of the internal pudendal, the artery to the bulb and the penile artery then arising as branches of the prostatic artery. I have not been able to confirm the statement of Poirier who states that the perineal artery is larger in the female. The perineal artery courses over or under the superficial transversus perinei muscle in the superficial perineal interspace, becomes superficial, terminating on the posterior surface of the scrotum in the male and on the labia majora in the female. In three subjects the posterior scrotal artery is replaced by a branch of the external spermatic artery. The deep branch (*A. transversus perinei*) of this vessel courses transversely toward the median line, vascularizes the bulbocavernosus, ischiocavernosus, the sphincter ani muscles and superficial muscles of the perineum, the vessel anastomosing with its fellow of the opposite side.

Waldeyer describes the perineal artery as giving the following branches: (a) Branch to ischiocavernosus; (b) skin of the perineum and inner side of the thigh (the latter may arise as a separate branch of the internal pudendal); (c) a vaginal branch to the vestibule (in 50 per cent. of the subjects); (d) a branch to the bulbus urethrae or bulbi vestibuli vaginæ (*A. bulbi urethrae*; *bulbi vestibuli vaginæ*). This vessel usually arises from the deep perineal artery between the layers of the triangular ligament and about  $\frac{1}{2}$  cm. above the level of the base of the trigonum urogenitale (triangular ligament). It is a large vessel in the male and courses transversely toward

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the median line and pierces the superficial layer of the triangular ligament. The branch to the bulb divides into a number of rami and gives off a ventral branch to the corpus cavernosum and a branch to the glandula bulbo-urethralia (Cowper's gland) and anastomoses with the bulbar artery of the opposite side.

This vessel arises 14 times as a branch of the prostatic artery. It occasionally occurs as a branch of the inferior hemorrhoidal artery. It arises as a separate branch from the perineal artery in 11 per cent. of the subjects. The bulbo-urethral artery is represented as a twin vessel twelve times.

*Arteria urethralis* (bulbourethralis of Kobalt) usually arises in the deep perineal interspace from the deep perineal artery ventral to the origin of the bulbar artery, pierces the superficial layer of the ligament and enters into the sulcus between the corpus cavernosa and corpus spongiosum. This vessel gives origin to one or two branches to the root of the corpus cavernosa, enters the corpora of the same side and courses to the glans penis and anastomoses with the dorsalis and profunda penis arteries.

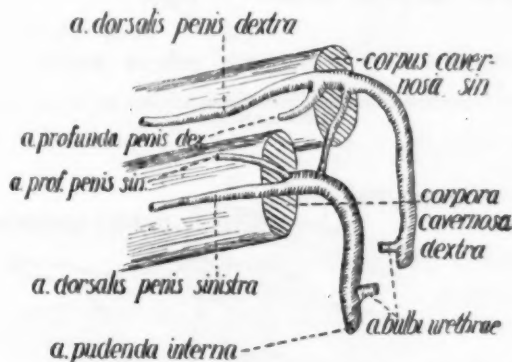


FIG. 7.—Illustrates the presence of an anastomotic branch between the dorsalis penis arteries dorsal to the origin of the profunda penis and occurs in 15 of the arteries studied. Figs. 7 to 11 illustrate unusual variations in the profunda and dorsalis penis arteries.

*Arteria dorsalis penis* (or *clitoris*): Cruveilhier and Poirier consider this vessel as the terminal artery of the internal pudendal. Henle and Sappey consider both the profunda penis and the dorsal artery of the penis as terminal arteries of the internal pudendal. The dorsalis penis artery is the continuation of the internal pudendal beyond the origin of the profunda penis. This vessel follows its usual course and distribution in only less than one-half of the cases observed. In the remaining subjects, it presents variation in its point of origin, in its branches and in the presence of anastomotic rami. Every artery observed in the latter group presents some variation; the latter are so numerous that I will only note the more important and conspicuous variations.

The arteriæ profunda penis and dorsalis penis are considered under a single heading because of their close relation.

An anastomotic branch is found between the dorsalis penis arteries dorsal (or proximal) (Fig. 7) to the origin of the profunda penis artery in

15 of the cases observed. This transverse anastomotic branch occurs three times ventral (or distal) (Fig. 8) to the origin of the profunda penis artery, and gives origin to a double left profunda penis; the right profunda penis arising as a branch from the right penile artery dorsal to the anastomotic branch. In one subject both profunda penis arteries unite and after a course of 1 cm. redivide again into the right and left profunda penis arteries.

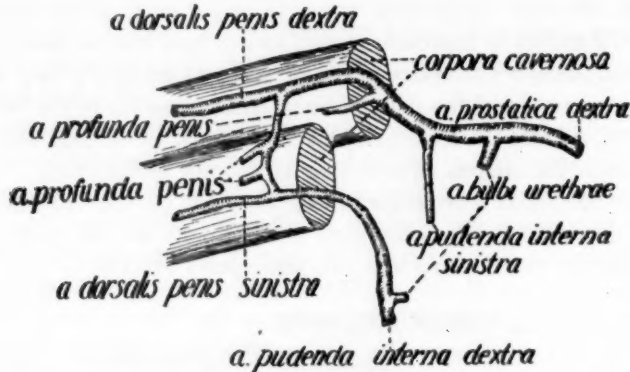


FIG. 8.—Represents the transverse anastomotic branch ventral to the profunda penis artery. This occurs in three subjects.

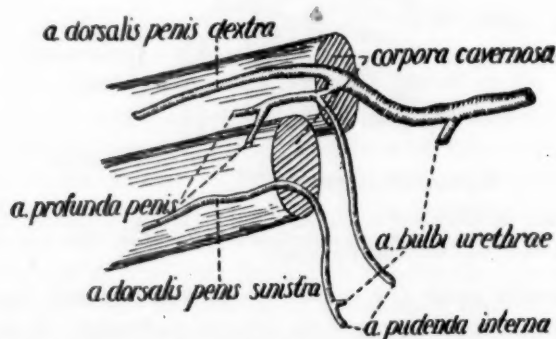


FIG. 9.—Represents the origin of the right dorsalis penis artery from the prostatic; and the former artery gives origin to a branch which is a common trunk for the right and left profunda penis arteries. This occurs in six of the subjects studied.

The right dorsalis penis artery arises from the right prostatic artery and gives origin to a branch which is a common trunk for the right and left profunda penis arteries (Fig. 9); the profunda of the left side is absent. This arrangement is found six times. An accessory profunda penis which arises from the inferior vesical occurs four times.

In two cases the left dorsalis penis artery arises from the inferior vesical artery (Fig. 10); in these subjects both profunda penis arteries arise in a common trunk from the internal pudendal artery. This common trunk presents an anastomotic branch with left penile artery which arises from the inferior vesical.



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In 5 subjects the right internal pudendal terminates as the profunda penis artery, in these subjects the left prostatic continues forward and gives origin to the right dorsalis penis artery, the trunk then divides into the left profunda and left dorsal penis arteries.

In 7 of the cases observed both profunda penis arteries redivide and have a bilateral distribution (Fig. 11).

The dorsalis penis arises in two of the cases observed as a branch of the obturator.

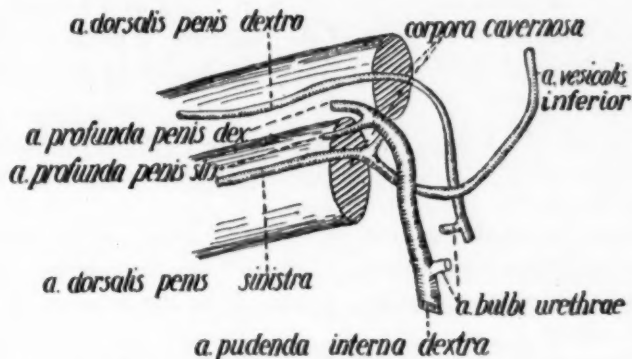


FIG. 10.—Represents the origin of the left dorsalis penis artery from the inferior vesicle. This occurs in two of the arteries studied.

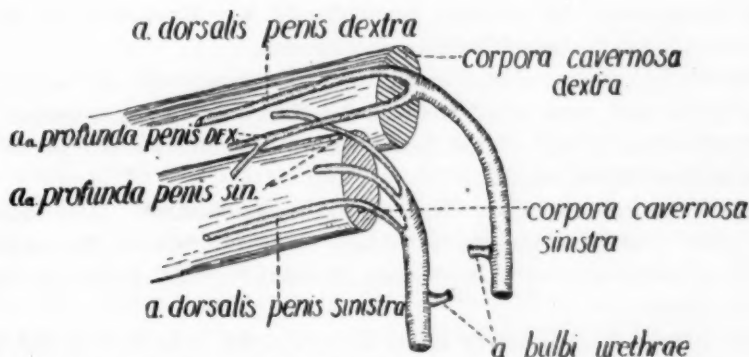


FIG. 11.—Represents both profunda penis arteries as having a bilateral distribution. This arrangement occurs seven times.

The middle hemorrhoidal and prostatic arteries are found frequently as branches of the internal pudendal.

Ischassow has described several anomalies of the pudendal artery, 2 cases in which the penile artery arises from the obturator; 1 case in which the penile and bulbar arteries arise from the prostatic, the prostatic artery coursing lateral to the pelvic-prostatic capsule of Retzii. Wassiliw in 100 cases demonstrated in 19 anomalies of the penile artery; the latter vessel arises in two subjects from the obturator, 3 times as a branch of the vesiculo-

prostatic and in one subject from a proximal point in the normal pudendal artery. The course of the anomalous branch is always the same along the base of the bladder and prostate.

*Arteria hemorrhoidalis media:* This vessel is not constant. It is present in only 72 per cent. of the subjects observed. It varies in its calibre and origin. The middle hemorrhoidal artery arises most frequently as a branch of the internal pudendal. This origin occurs in 54 per cent. of the cases observed.

The *middle hemorrhoidal artery* arises 41 times as a branch of the inferior gluteal, 5 times as a branch of the obturator, 3 times as a branch of the vesiculodeferential artery and 3 times as a branch of the anterior trunk of the hypogastric artery.

In 15 per cent. of the subjects studied, this vessel is found double, the branches arising either from the internal pudendal or the anterior trunk of the hypogastric artery.

The middle hemorrhoidal not infrequently arises in a common stem with the vesiculodeferential artery, 10 times from the internal pudendal, 4 times from the inferior gluteal and 3 times from the anterior trunk of the hypogastric artery.

The blood supply of the middle hemorrhoidal to the rectum is not important. The principal blood supply of the rectum is the superior hemorrhoidal artery. Waldeyer affirms this anatomic fact. The anastomosis between the superior and inferior hemorrhoidal is submucous, that of the superior and middle hemorrhoidal subperitoneal.

The middle hemorrhoidal divides into 2 to 4 rami to the lateral parietes of the pelvis and gives small rami to the obturator internus, gemelli and pyriformis muscles, and in the female partly vascularizes the lateral and dorsal surfaces of the vagina.

*Arteria vesicalis inferior:* This vessel is not constant. It is found in only 70 per cent. of the subjects studied. Poirier describes this vessel as rising in a common trunk with prostatic, vesicodeferential or middle hemorrhoidal arteries.

The inferior vesical artery arises as a separate branch from the prostatic artery in 34 subjects studied. It occurs 3 times as a branch of the vaginal, 8 times as a branch of the umbilical distal to the uterine artery, 9 times as a branch of the vesiculodeferential artery, and 5 times as a branch of the internal pudendal artery.

This vessel occasionally replaces one or more of the branches of a defective internal pudendal artery; cases of this type are noted in a description of the latter vessel.

*Arteria deferentialis:* This vessel is homologous to the uterine in the female. It is constantly observed. It occurs most frequently as a branch of the anterior trunk of the hypogastric artery. This vessel is found 4 times as a branch of the middle hemorrhoidal, 3 times as a branch of the interior

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pubdental and in 2 subjects as a branch of the prostatic artery. The deferential artery occasionally replaces the internal spermatic artery.

*Arteria uterina:* The uterine artery is the homologue of the deferential artery in the male and arises more commonly second in order as a well-marked vessel from the ventral or anterior trunk of the hypogastric artery. This vessel occurs four times in a common trunk with the superior vesical artery; in two cases in a common trunk with the internal pudental and in one subject in a common trunk with the obturator. The uterine artery pursues a tortuous, medially directed course, insinuates itself between the layers of the broad ligament, and courses along its base. On approaching the neck of the uterus it usually divides into ascending branch running along the side of the uterus and a descending branch to the cervix. The ascending branch supplies the body of the uterus, and in this part of the course it gives off branches to the ventral and dorsal surfaces of the uterus which anastomose with the corresponding branches of the opposite uterine. The latter vessels diminish greatly in calibre as they pass forward to the medial line. The uterine artery usually gives origin to a branch to the fundus uteri; and two lateral branches: (a) Ramus tubarius, which anastomoses with the tubal branch of the ovarian artery; (b) a branch to the ovary (R. ovarii), which anastomoses with the ovarian. The latter branch gives a number of small branches to the broad ligament, which anastomose with the inferior epigastric. The uterine artery also gives off a number of small rami to ureter and bladder.

The uterine artery at its origin lies at a deeper level and lateral to the ureter. At the level of the spine of the ischium, the uterine artery enters the broad ligament to reach the uterus and in its course along the base of the broad ligament passes ventrad to the ureter.

The distance between the right and left ureters at the point of crossing between the ureter and uterine artery is from 6.5 to 7.5 cm., and 4 cm. at the level of the ostium externum uteri.

In one subject the uterine artery arises bilaterally in a common trunk with the internal pudental and at a more caudal level than the normal uterine; the uterine artery courses slightly lateral and dorsal to the ureter, and at the point of crossing, the uterine artery passes dorsal to the ureter.

This unusual relation of the ureter ventral to the uterine artery is evidently of the rarest occurrence. The writer could not find a single instance in the literature in which this anomalous relation was reported.

This unusual relation should be borne in mind by the surgeon in ligation of the uterine artery, in order that he may avoid injury to the ureter.

*Arteria vesicalis superior:* This vessel represents the persistence of the proximal end of the umbilical artery in the foetus. It arises four times in a common trunk with the uterine artery and also occurs in a common trunk with the vaginal and obturator arteries. The superior vesical artery divides into numerous branches (Rami vesicales) which supply the apex and body of the bladder and anastomose with the corresponding vessels of the opposite side.

## SECTION D—SUMMARY AND DISCUSSION

1. A comparison of the types of the arteria hypogastrica demonstrates the predominance of Type I on both sides of the body. This arrangement of the branches of the hypogastric artery occurs in 40 per cent. of the arteries studied, 24 per cent. on the right side of the body and 16 per cent. on the left side.

Type II occurs in 24 per cent. of the arteries observed, 14 per cent. on the right side and 10 per cent. on the left side; Type III in 17 per cent.; Type IV in 11 per cent. of the subjects, and Type V in 7 per cent.

A similar arrangement of the branches on each side of the body is present in 35 per cent. of the cadavers observed.

2. This study embraces the dissection of 93 cadavers: 72 male white, 11 female white, 7 male negro and 3 female negro. There are 91 dissections from the right side of the body and 90 dissections from the left side.

No relation of the branches to age could be drawn as there were only adults in this series. In the study of the femoral artery, the negro subjects presented a greater proportionate number of variations and anomalies than the white. Twelve per cent. of the dissections of this study were made on negro subjects. The latter subjects did not present proportionately a greater number of variations and anomalies. Unusual variations occur with greater frequency on the left side of the body.

3. Many of the variations which are found in studying the arterial tree in man, occur as normal types of vessels in lower forms. There is a normal type for each order. The careful comparative anatomy studies of Zuckerkandl and Popyski fail to disclose any well defined gradation of changes or laws upon which to base explanations of the genesis of variations. Tandler in his careful research and studies on the arteries of the head in animals affirms this anatomic fact, yet comparative anatomy appears to indicate that there has been a progressive change toward well defined types. It is reasonable to assume that in the higher mammals the arterial system is as complex as it is in man and that arterial variations occur with the same degree of frequency. This phase of the study of arterial variations—the explanation of their genesis on a comparative anatomy and embryologic basis, will be presented in detail in a later study.

4. The middle hemorrhoidal artery is found in 72 per cent. of the subjects observed. This vessel occurs most frequently as a branch of the internal pudendal (internal pudic) artery. The middle hemorrhoidal is frequently present as a separate branch arising from the inferior gluteal artery. In 15 per cent. of the subjects the middle hemorrhoidal is represented as a double vessel. The blood supply of the middle hemorrhoidal to the rectum is not important. The principal blood supply of the rectum is the superior hemorrhoidal artery. The anastomosis between superior and inferior hemorrhoidal is submucous, the anastomosis between the superior and middle hemorrhoidal arteries is subperitoneal. The middle hemorrhoidal also partly vascularizes the lateral and dorsal surfaces of the vagina. The vaginal

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artery usually vascularizes the lateral surface of the vagina. The vaginal artery is represented as a twin vessel in 40 per cent. of the subjects of this series.

The inferior gluteal artery arises in a common trunk with the superior gluteal artery in 24 per cent. of the arteries classified, the inferior gluteal artery in 40 per cent. of the arteries studied arises in a common trunk with the internal pudendal artery. This ischiopudendal trunk in 25 per cent. of the subjects divides into the inferior gluteal and internal pudendal arteries after it has made its exit from the pelvis.

The inferior gluteal artery in 16 per cent. of the cases observed is represented as a twin vessel, each of which has a separate origin.

The arteria perforans ligamentum sacrotuberosum is one of the terminal branches of the inferior gluteal and is usually a vessel of large size, coursing between the fibrous layers of the sacrotuberous ligament. The R. inferior internus represents the caudal continuation of the inferior gluteal artery. This vessel not infrequently pierces the sciatic nerve, separating its nerve fibres and becomes ensheathed by the fascia covering the sciatic nerve.

The iliolumbar artery is found absent 5 times, in which subjects it is replaced by the fourth lumbar artery.

The superior gluteal is the largest branch of the hypogastric artery and in the adult is the direct continuation of the hypogastric artery. The superior gluteal artery courses between the lumbosacral trunk and first sacral nerve. This vessel makes its exit from the pelvis through the great sacro-sciatic foramen (foramen ischiadicum majus) cephalic to the pyriformis muscle, as it passes above the pyriformis muscle, it is rarely of any length, never more than 1 cm., and divides into a variable number of large arborescent branches.

The internal pudendal arises in 40 per cent. of the cases classified in a common trunk with the inferior gluteal artery; in 24 per cent. it arises as a separate branch from the anterior trunk of the hypogastric artery.

The internal pudendal terminates 28 times as the perineal artery, the prostatic replacing the vessels of the defective internal pudendal artery. Anastomosis between the penile arteries on both sides of the body is frequent in the male. The penile artery at times has a bilateral distribution. The dorsalis penis and profunda penis may arise from the prostatic artery, less frequently from the inferior vesical and obturator arteries. Approximately one-half of the dorsalis penis and profunda penis arteries present variations.

The obturator artery arises in a common trunk with the inferior epigastric artery in 19.3 per cent. of the subjects studied. The obturator arises not infrequently as a separate branch from the superior gluteal artery. The obturator artery occurs three times as a branch of the external iliac, and in two cases as a branch of the femoral artery. The obturator artery also occurs as a branch of the inferior gluteal artery, internal pudendal artery, the ischiopudendal trunk and the common trunk for the superior and in-



ferior gluteal arteries. The obturator artery is represented as a twin vessel in 11 of the cases observed.

The obturator artery varies in its relation to the femoral ring in accordance to its origin. 1. If it arises from the external iliac artery, it bears little or no relation to the femoral ring. 2. If it arises from the femoral artery and there is a hernia present, the obturator artery is usually caudal and dorsal to the femoral ring. In about one-half of the cases in which the obturator artery arises from the femoral artery, it is related to the outer half of the femoral ring and in this position it is likely to be injured and result in dangerous hemorrhage. To avoid this injury incise the iliopubic ligament as near as possible to the lacunar (Gimbernat's) ligament. 3. If it arises with deep epigastric artery, the relation of obturator artery to femoral ring varies in proportion to the height of its origin—(a) if it arises below (Poupart's) inguinal ligament, its course is lateral to the hernia; (b) if it arises above inguinal ligament, it pursues an arched course and is medial to the femoral ring. In a number of latter subjects, the obturator artery is lateral to the femoral ring.

The ramus pubicus superior arises occasionally at the inner edge of the femoral ring. This vessel is at times of large calibre and is easily injured in operative procedures in this anatomical region.

The aorta bifurcates most frequently at the level of the fourth lumbar vertebra.

The common iliac artery is usually from 4 to 6 cm. in length and divides most commonly between the fifth lumbar vertebra and the superior margin of the sacrum. The hypogastric artery varies in length from 2 to 5 cm. and its point of division varies from the superior margin of the sacrum to the upper border of the sacrosciatic foramen (foramen ischiadici majus).

The uterine artery usually arises from the anterior trunk of the hypogastric artery as its second branch. It enters the base of the broad ligament opposite the spine of the ischium, and in its course to the uterus passes ventrad to the ureter. This point of crossing occurs at the level of the ostium uteri interni. The right and left ureters are from 6 to 7.5 cm. distant from one another at the point of crossing and 4 cm. at the level of the ostium uteri externi.

In one subject the uterine artery arises on both sides of the body in a common trunk with the internal pudendal arteries. In the latter subject the uterine artery courses slightly lateral and dorsal to the ureter and at the point of crossing the uterine artery passes dorsal to the ureter. This unusual relation of the ureter being ventral to the uterine artery at the point of crossing is of the rarest occurrence, and should be borne in mind by the surgeon in ligation of the uterine artery, in order that he may avoid injury to the ureter.

Ellis, Eckhard and Ledwich have recorded cases in which the hypogastric (internal iliac) artery is absent on the left side of the body and its

## STUDY OF THE HYPOGASTRIC ARTERY

branches derived from a root of the external iliac artery dipping into the pelvis. This unusual variation is not observed in this study.

This study again illustrates the fact that the observation and classification of any one of the large arterial trunks of the body in a sufficiently extensive series of cadavers allow of a natural grouping into distinct types. The descriptions of the arterial trunks as contained in standard anatomical textbooks conform usually to but one type. The usual and accepted conventional opinion that whenever a vessel occurs which is at variance with a classic textbook description it is an anomaly, needs to be revised. In studying a large number of arteries of any one of the large arterial trunks, certain variations are found to occur with sufficient frequency to justify the establishment of distinct groups. At times variations occur which differ so widely from the normal types of the vessel that they cannot be classified, these alone should be termed anomalous. In the present study, every vessel observed conformed to one of the types. In the previous studies of the femoral and coeliac axis arteries only less than two per cent. of the arteries observed were at variance to the described types.

This interesting phase of anatomical study—the establishment of anatomic types—brings together in a concrete and definite form all the possible variations of the particular artery. A knowledge of the types of the larger arterial trunks will aid the surgeon in avoiding troublesome and dangerous hemorrhage that otherwise could not be averted, and it is incumbent that he move slowly in operative procedures until he has determined the exact anatomy of the part. A constant variation in size, calibre and number of branches (defective arteriogenesis) is undoubtedly an etiological factor in the production of certain pathologic conditions.

My best thanks are due to Professor J. Parsons Schaeffer, Head of the Department of Anatomy, for his permission to make liberal use of all the material in his department and for his constant attention, interest and criticism in this study.

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## FRACTURE OF GREAT TOE SESAMOID BONES

BY THOMAS GROVER ORR, M.D.  
OF KANSAS CITY, MO.

CASE REPORT.—In September, 1916, Doctor S., age about fifty years, while mowing his lawn, stepped on some hard object in the grass, causing a sharp, sudden pain beneath the right great toe at the metatarsophalangeal joint. He wore a shoe with a very thin sole, making indentation by a hard object very easy. The pain continued, when walking, more or less severe for two weeks. No swelling or redness was noted at any time, but there developed some thickening in the region beneath the joint. An X-ray taken at this time showed a transverse fracture of the right tibial sesamoid bone without separation of the fragments. Two weeks after the primary injury, while hunting doves, the patient stepped into a small post-hole, injuring the foot again in the same place. The post-hole was just large enough to catch the heel and toe of the shoe, hyperextending the great toe. The pain was so severe at this time that the patient dropped to the ground and was unable to bear any weight on the foot for several minutes. He later walked with difficulty for a half mile. No swelling or redness was noted at this time. Two weeks after the second injury, another radiograph was taken which showed a definite separation of the two fragments of the previously fractured bone (Fig. 1). The corresponding bone of the opposite foot was normal.

It was thirty days before any treatment was begun. There was more or less constant pain at the site of the fracture during this time. At the suggestion of Dr. W. J. Frick a large bunion plaster was strapped beneath the joint with adhesive. This treatment completely relieved the symptoms. For two weeks the patient used crutches, keeping the injured foot from the ground. For eight or ten weeks thereafter, he walked with a cane, stating that he was "always conscious that something was wrong" beneath the base of the great toe. Eleven months after injury there was still some pain when walking on rough, uneven ground. Eighteen months after the patient could walk without difficulty. There was no disability and he considered himself cured. The X-ray shows bony union between the two fragments (Fig. 2).

The sesamoid bones beneath the great toe are situated one in each head of the flexor brevis hallucis. The dorsal surfaces of the bones enter into the formation of the metatarsophalangeal joint. They are concave on the dorsal and convex on the ventral surface, and are joined together by fibrous tissue and the capsular ligament in such a manner that a groove is formed on the plantar surface for the passage of the flexor longus hallucis. The median, or tibial, bone is situated directly under the head of the first metatarsal and the lateral, or fibular, extends beyond the head laterally, as shown

by the radiograph. This anatomical difference may account for the more frequent fracture of the inner bone. The sesamoid bones beneath the great toe are the largest in the body, except the patella. These bones are constantly present and are a definite part of the human osseous structure. They are sometimes congenitally divided into two or more parts, especially the tibial sesamoid. A percentage as high as sixteen has been found in which one or more bones were divided in the examination of one hundred normal feet. The size of the bones has been given as 12 to 15 millimetres long by 9 to 11 millimetres wide for the tibial and 9 to 10 millimetres long by 7 to 9 millimetres wide for the lateral. The centres of ossification appear between the eleventh and fourteenth years.

TABLE OF REPORTED CASES OF FRACTURE OF THE GREAT TOE SESAMOID BONES

Reported by	Year	No. of cases	Bone fractured	Sex	Age	Direct or indirect violence
Schunke.....	1901	1	Right tibial	M	42	Direct
Marx.....	1904	1	Right tibial	M	40	Direct
Polak.....	1906	1				
Muskat.....	1906	1	Right fibular	M	50	Indirect
Momberg.....	1907	2	Right tibial	M	..	Direct
			Right tibial	M	..	Direct
Stumme.....	1908	2	Right tibial	M	..	Indirect
			Left tibial	M	40	Direct
Igelstein.....	1908	1	Right fibular	M	22	Direct
Morian.....	1909	5	Left tibial	M	32	Direct
			Left tibial	M	49	Direct
			Right tibial	M	30	Direct
			Left tibial	M	23	Direct
			Left tibial	M	14	Direct
Painter.....	1910	1	Right tibial and fibular	M	66	Direct
Royer.....	1911	1	Right fibular	M	..	Direct
Müller.....	1912	1	Left tibial	F	35	Direct
Speed.....	1914	5	Left fibular	M	..	Direct
			Left tibial	M	..	Direct
			Right tibial	M	..	Direct
			Right tibial	M	..	Direct
			Right tibial	F	..	Direct
Boardman.....	1915	1	Right tibial	F	25	Indirect
Eiken.....	1916	1	Right tibial	F	38	Direct

Fractures of the great toe sesamoids have, in a large percentage of instances, been produced by direct violence. A history of a weight falling on the dorsum of the foot, a squeezing or crushing injury, a fall from a height with greatest weight over the sesamoids, or a sudden increase in weight bearing are among the commonest etiological factors. The case here reported was, primarily, one of sudden increase in weight bearing produced by pushing a lawn mower. Cases are reported in which the injury was produced by indirect violence and it has been shown that the fracture can be produced experimentally by forcible hyperextension. The injury occurs more frequently in the male during the active period of life between the ages of twenty and fifty years. The youngest case reported was fourteen years of age and the oldest sixty-six. There have been 24 cases of fracture



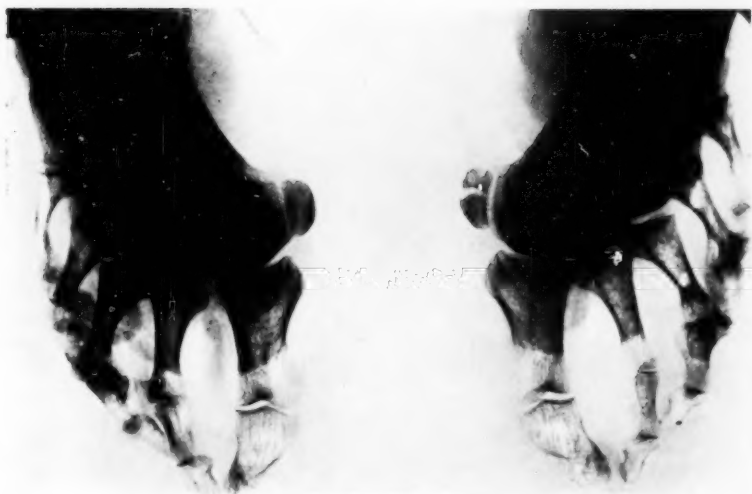
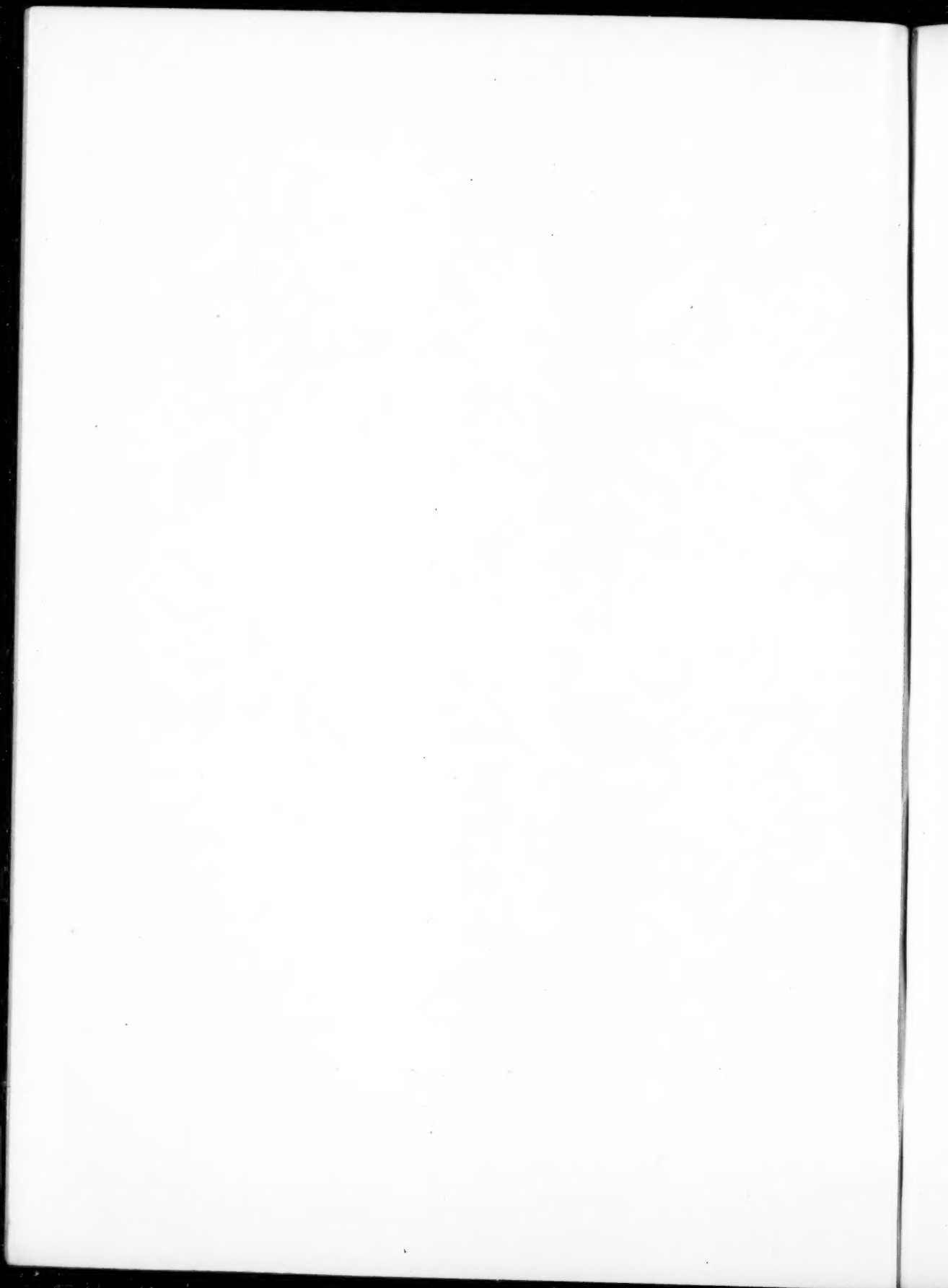


FIG. 1.—Fracture of the tibial sesamoid.



FIG. 2.—Same as Fig. 1, after bony union.



## FRACTURE OF GREAT TOE SESAMOID BONES

of the great toe sesamoids reported in the literature up to the present time. The accompanying table contains a list of the recorded cases.

Very little pathology is produced by the fracture alone. If the injury is produced by a weight falling upon the foot, there may be considerable trauma of the soft parts about the great toe. The fragments may be completely separated, but usually the separation is not great. There is often some inflammatory reaction about the joint with considerable thickening of tissue, especially on the plantar surface. Tenosynovitis in the sheath of the flexor brevis hallucis may develop.

The most pronounced primary symptom of fracture of the great toe sesamoids is sudden sharp pain at the time of the injury. This pain may be obscured by the more severe pain due to more extensive injury of the foot. There is some disability at once, the patient being unable to bear weight on that portion of the foot without pain. The disability may continue, more or less severe, over a long period of time unless satisfactory treatment is instituted. Tenderness in and about the great toe joint is generally quite marked, with often some swelling and, at times, redness. There is tenderness on palpation and pain on passive motion. Crepitus is rarely elicited.

The diagnosis of the condition is to be emphasized because of the frequency of mistakes. The fracture has frequently been considered a sprain or bruise and treated with liniments and hot fomentations. After a short rest the symptoms disappear and the patient is considered cured, only to have a recurrence when the use of the foot is resumed. A case is recorded of a nurse who was treated with a metal arch support by an orthopædic surgeon, and later for rheumatism, by an internist. Congenital division of the bones must be carefully considered. Momberg has concluded that the cases reported by Schunke and Marx belong to this class. Igelstein thought his case might be one of congenital division. Painter's cases are also doubtful fractures. Several of the reported cases were not diagnosed for several months after the injury. The primary diagnoses that have been made have included almost all types of great toe joint disease from arthritis deformans to metatarsalgia.

The prognosis is good if the condition is recognized and properly treated. Some cases have complete bony union between the fragments. There may be considerable thickening at the site of the fracture with prolonged tenderness when weight is borne on the foot.

The best treatment, immediately after injury, is rest. Unless the rest is prolonged, it is usually not curative. The symptoms return in quite a large percentage of the cases when the use of the foot is resumed. The shoe can be constructed with a depression in the inner sole to relieve the pressure over the bone. A large bunion pad may be strapped beneath the joint with adhesive, as was done in the case reported. If, after reasonable conservative treatment, the part is still painful and causes disability, the fragments should be excised. When operation is necessary, it is advised by Speed that both sesamoid bones be removed, as it produces a better functional result.

THOMAS GROVER ORR

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# TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY

*Stated Meeting, held December 3, 1917*

The President, DR. CHARLES H. FRAZIER, in the Chair

## OSTEO-ARTHRITIS FROM FOCAL INFECTION

DR. WILLIAM J. MERRILL presented a number of patients to demonstrate the relation between arthritis and tonsillar and dental infections. He prefaced the presentation of these patients by remarking that inflammations arising in joints, muscles, tendons, etc., are due to bacterial infections or intoxications or physiologic poisoning. The tissues in normal conditions, under normal and even abnormal stress, do not undergo any permanent pathological change. If the tone and resistance are diminished and the cells are irritated, slight stress produces morbid change in the parts which are weakest. The effects of traumatism in normal tissues are readily repaired and the tissues return to their normal condition readily, except when there is some constitutional disorder which keeps up the irritation. Arthritis from traumatism readily recovers except when there is a toxic or infectious agent present, under which condition the arthritis may remain subacute or chronic for a considerable time. Even in the case of dislocation or severe traumatism in which there is considerable solution of continuity, when poisons are not present, repair takes place readily. He had seen marked evidence of this fact within the past seven years, in which time mild and severe cases of arthritis have been noted to exist in the presence of focal infection and which have cleared up when the source of poison was eliminated.

Six and a half years ago, a severe case of hypertrophic osteo-arthritis of the hip-joint, in which there were already hyperostoses of the joint and limited motion in the hip-joint, recovered, and nearly normal motion returned after three teeth had been removed and the infection eliminated.

A large number of cases of "sacro-iliac relaxation," "sacro-iliac strain," "sacro-iliac sprain," etc., have recovered when nothing more was done than to treat the focal cause. Many cases of arthritis and localized inflammatory states in the spine are due to physiologic poisoning. From observation of these many cases of pain and tenderness in the spinal and pelvic structures, it has been proven conclusively that when any irritation is continued there is some bacterial or physiologic poisoning to "fan the flame"; furthermore, that in all irritation in a joint or other structure there must be a constitutional toxic state when the condition persists. In cases of mild pain in the sacro-iliac and lumbosacral structures, continued for a long time, and the severe prostrating attacks which might be termed "sacro-iliac crises," the evidence has been in many hundreds of cases very conclusive that the



condition was due primarily, as a predisposing cause, to systemic poisoning, and secondarily, as an exciting cause, to traumatism.

It is not possible to determine from the external appearance of a tooth whether it is infected or not, since many teeth are apparently not devitalized but are in the first stages of the infected condition. The tooth is infected by the invasion of bacteria to the root canal, which may take place by means of erosion through the dentine or enamel, which is chemical dissolution, or by means of abrasion, which is mechanical dissolution. The process of erosion takes place especially in the sulci of the crown and at the neck of the tooth at the junction of the enamel and the pericementum under the margin of the gum. When the dentine is encroached upon, the dental tubuli are opened up and bacteria can pass directly into the tooth. If an abrasion or lesion takes place in the pericementum, then by continuity the infection may travel external to the dentine up to the apex of the tooth and enter the root canal. The formation of tartar underneath the gum is a very frequent cause of erosion. When organic matter is lodged in the margin of the gum, chemical and bacteriochemical action takes place, especially when traumatism is added. Bacterial plaques are formed which adhere to the tooth. Calcification takes place and tartar is formed. Under this tartar, erosion occurs.

When teeth have lost their normal whiteness or have become discolored, they are undoubtedly in the stage of early infection or totally devitalized. Such condition, often when there is no tenderness or pain, should be suspected. The teeth should be X-rayed. When the tooth is devitalized and the abscess involves not only the apex but more or less of the alveolus, it should be extracted. Pivots in the stumps and roots of devitalized teeth, especially when the root canal filling is incomplete, are very frequently sources of infection. Pyorrhoea, especially when it is superficial, does not necessarily cause any constitutional disturbances because, as a rule, under this condition, there is no absorption and the pus which collects and is swallowed is unquestionably neutralized in the stomach.

Focal infections in the tonsils, nasal cavities, sinuses, along the intestinal tracts, such as infected glands, appendix, gall-bladder, in the genito-urinary tract, such as prostatitis, seminal vesiculitis, infected tubes, etc., are unquestionably frequent causes of various forms of arthritis.

DR. WALTER G. ELMER confirmed the statement that infection about a tooth can be disseminated throughout the body and cause serious difficulty. At one time he was himself apparently the victim of faulty dentistry. A week or two after a filling had been removed he began to have pain in the whole upper jawbone, and bore with it as patiently as possible for about three months. As the pain grew steadily worse instead of better he consulted another dentist who drilled through the filling, and about a thimbleful of pus escaped. There was instant relief. It was a front tooth and the pus had evidently burrowed over the upper surface of the hard palate. This is a typical instance in which the local infection may cause serious disturbance elsewhere, as in a joint which had received some slight traumatism.

## OSTEO-ARTHRITIS FROM FOCAL INFECTION

On the other hand, a certain amount of conservatism should be used. He related the experience of a friend who, during a visit to another city where great interest and enthusiasm were shown in tooth infection, was persuaded to have X-ray pictures made of his teeth. He was in perfectly good health and, so far as he knew, his teeth were in excellent condition and caused him no trouble whatever. But it was concluded from the X-ray films that he had seven teeth with abscesses at the roots and he was urged to have them extracted at once; otherwise he was marching straight to his doom! However, he demurred, and returned to Philadelphia with all his teeth.

It would be interesting to determine in a series of about 5000 examinations how many gave evidence of certain shadows indicating foci of infection at the roots of the teeth. An inflammatory process in the pericementum at the root of a tooth may subside entirely, leaving behind it only clean healthy tissue, and yet this area will cast a shadow of different density from that one in which there has never been any inflammatory process. Even a circumscribed abscess may become absolutely sterile. It often happens that no culture can be obtained from an old pyosalpinx. And yet such a condition at the root of a tooth would cast its shadow on the film. Children who have had their teeth straightened show changes in the density of the shadows about the roots, but that does not mean infection there because there never has been any infection. It is due to the shift in the position of the root.

A very large proportion of people must have these evidences who are nevertheless enjoying good health. The subject must be viewed in that light and not without caution. Perhaps in the conduct of the orthopaedic clinics sufficient attention may not be given to the teeth, but a large number of the joint conditions improve under the usual methods of treatment without having teeth extracted. There are two sides to the question: one in which the matter is overestimated, the other in which the teeth are neglected altogether.

DR. MERRILL, in closing, remarked that patients are always carefully examined in the dispensary. If there is any suspicion of trouble in the mouth, they are sent to the Dental School. Practically 100 per cent. who have been sent to the Dental Clinic have had some mouth lesion. What the percentage of persons not examined in this manner is, it is impossible to state. In regard to ignoring the evidence given by X-ray, it is unquestionably an unwise attitude, even though in certain cases of marked caries of teeth and of the alveolus there is often but little trouble, since the "fires have burned out." Again the X-ray may not show any absorption, erosion or abscess because it is too small to cast a shadow.

In several cases, X-rays have indicated a large amount of erosion and absorption and that the cavities were filled with pus. On extraction there was practically no free pus but infection was present. The associated disabilities which we practically always find act as our guide, and as a rule the affected teeth which are the predisposing cause are extracted.

## PHILADELPHIA ACADEMY OF SURGERY

A frequent cause of trouble which is not evident on inspection or X-ray examination is a small abscess at the roots of the tooth. The period when the infection is most likely to take place is in the beginning of the formation of this abscess. With these facts in mind, the importance of careful and repeated search is emphasized. If the abscess is not shown by the X-ray taken in a given angle, it should be taken at various angles with a hope of finding the pus cavity. Many times it will be hidden behind the apex of a root and not show. In certain cases referred to, in which there were decided symptoms, such as nerve pain and joint conditions, the abscess at the apex of the extracted tooth was about the size of a pinhead.

The symptoms have subsided in practically every case which was treated at the Dental Hospital, or at least at the present writing, cases which returned to the dispensary have shown improvement or cure. It is, of course, impossible to state the percentage of persons who have apical or alveolar abscess and are apparently in good health.

### SURGERY OF SPASTIC PARALYSIS

DR. A. BRUCE GILL read a paper with the above title, for which see page 529.

DR. GWILYM G. DAVIS said that he thought that the operation on the brain for the localized traumatism resulting in paralyzes did not originate from Doctor Sharpe's suggestion, but rather from Cushing's. He had been over the same material mentioned by Doctor Gill in reference to the examination of the eyeground. Cerebral decompression is obviously a measure intended to lessen the pressure inside the skull, and one of the symptoms of such pressure is clouding of the optic nerve as observed by the ophthalmoscope and that is what one universally fails to find. A child with spastic paralysis, even at the age of two years, does not have the use of the limbs which it should have at that period. The condition is called cerebral spastic paralysis and is often associated with an impaired mentality. Some of the evidences of that are very obscure and interesting. In the treatment of the cases, the old method of tenotomy still continues largely in force for two reasons: (1) the ease of its performance, its availability, and (2) because at times the results which it yields apparently compare favorably with those of other methods. He was not willing to go quite so far as does Doctor Gill in the advocacy of the Stoeffel operation, for his experience with it has not been so entirely favorable as his. He had not found it always an easy operation, being considerably more difficult than the tenotomies. He, too, had done it on two sides, but the difference has not been so great as to incline him on all occasions to prefer it to the tenotomy. It should be emphasized that by tenotomies and transplanting the condition in many of the cases can be improved. Doctor Nutt, of New York, some years ago divided the sciatic nerve deliberately, paralyzing the limb. He noticed considerable improvement in his patient, both in the parts affected and in the intelligence of the child. Encouraged by his results Doctor Davis divided the median nerve in

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the case of a young woman of eighteen years with contracted arm. She improved to such an extent that she later wanted the nerve divided a second time. Arrangements were made to do this but the patient's husband objected and the operation was not done. The Stoeffel operation would be followed by considerable improvement. He did not wish to appear antagonistic to this operative procedure because he believed it to be a good one. There are cases, however, such as children who rise a little too much on the toes when they walk or run, in which cure is effected by simple tenotomy and without the necessity of the more elaborate operative procedure. Yet there is a field for the Stoeffel operation.

DR. CHARLES H. FRAZIER remarked, with reference to resection of the posterior roots for the treatment of spasticity, there is no doubt that the operation is a very serious one and that the mortality is relatively high; there is no doubt also that there has been a considerable number of failures. It is easier to give the contra-indications for the operation than to give the indications. Certainly the operation should not be done in subjects not physically strong, in delicate children, nor in feeble adults. It should not be done for spasticity in the upper extremities. It should not be done when there is lacking good muscular reserve power, for when the spasticity is relieved, the function restored in the way of locomotion will not be sufficient to have warranted an operation of that gravity. It should not be done in children who are mentally defective, because the after-treatment is essential, no matter what the operation be, and unless the surgeon is assured of coöperation on the part of the patient the results will not only not be good but in most instances a failure.

Now with regard to the technic of the operation, he emphasized the point, that in the early stages there were many failures because too few roots were cut. For complete and reliable statements of what can be done by this operation he referred to Förster's own writings. He has done more root resections for spasticity than any other surgeon, and has been more painstaking in the follow-up treatment. The end-results depend upon the care in the selection of the roots to be cut and the persistence of the after-treatment. Förster's articles are profusely illustrated and afford an excellent demonstration of what can be accomplished.

The operation itself is attended with a risk greater than that of the ordinary laminectomy because one is dealing chiefly with large bundles of sensory roots and any insult to these must be a predisposing factor in the causation of shock or collapse. He had found that by the application to the cord and roots at the level of operation of a cotton pledget, saturated with a 0.4 stovain solution, shock could be eliminated. This is a simple procedure and it seems entirely rational. As a matter of fact he had proven by pulse and blood-pressure tracings its efficiency in the experimental laboratory.

Another point of great moment in the technic is the question of post-operative bleeding. A small artery accompanies each root and if we are



content with the mere section of the root with knife or scissors there will always be more or less postoperative oozing. A very little blood inside the dural sac will result in the formation of adhesions. Absolute hæmostasis is essential to the ideal operation. This can be applied with reference to root resection by ligation; in fact, he had done some of these operations without cutting the roots at all. With the finest silk suture he simply tied the ligature around the root. The root must undergo degeneration; regeneration cannot take place in the root any more than it can in the spinal cord or brain. By applying two ligatures and dividing the root between, the operation can also be made bloodless.

Theoretically, the operation is based upon sound physiological principles, but the technic is too difficult to warrant one's recommending it except to the neurological surgeon. Its successful performance requires great technical skill and dexterity and the mastery of many important manœuvres with which only those accustomed to the surgery of the central nervous system are familiar. With these restrictions he earnestly endorsed the operation in selected cases, and had practised it a number of times in his clinic.

From what Doctor Gill has said and from his own knowledge of the subject there is no doubt that the Stoeffel operation has a very much wider application. The principle of the Stoeffel operation is fascinating. His first experience with it was in the laboratory. In trying to devise an operation for the relief of deltoid paralysis, one of the most common sequelæ of infantile palsy and particularly deforming and undesirable in young women, it occurred to him that it might be possible and feasible to sacrifice a portion of the function of the triceps muscle for the benefit of the deltoid, using for this purpose a portion of the musculospiral nerve, representing the innervation of the triceps muscle. Extremely painstaking dissections were made in the cadavers of monkeys, newborn infants, and adults. With these he was able to confirm the observations of Stoeffel and at the same time familiarize himself with the topographical anatomy of the musculospiral nerves. In two monkeys he carried out an end-to-end anastomosis of the intentionally cut circumflex nerve with the electrically isolated portion of the musculospiral nerve. (In the monkey this represents approximately the posterior third of this nerve.) Immediately after the operation there seemed to be a complete musculospiral palsy with wrist-drop and inability to abduct the upper extremity. At the end of five months the wrist drop had disappeared and movements of the upper extremity were quite unrestrained. This was his first experience with the Stoeffel principle and it was sufficiently positive to convince him of its physiological soundness and the practicability of its application. So far as the effect of cerebral decompression is concerned in the treatment of spasticity he said that in the beginning he viewed the proposition with absolute skepticism and that nothing he had heard since had led him to change his views.

#### MASSIVE DEGENERATION OF THE KIDNEY AND ITS RÔLE IN THE CLINICAL CURE OF RENAL TUBERCULOSIS

DR. ALEXANDER RANDALL read a paper with the above title.



TRANSACTIONS  
OF THE  
NEW YORK SURGICAL SOCIETY

*Stated Meeting, Held January 23, 1918*

The Vice-President, DR. WILLIAM A. DOWNES, in the Chair

INJURY TO THE COMMON BILE-DUCT

DR. WM. A. DOWNES presented a man, forty-two years of age, who was admitted to St. Luke's Hospital November 30, 1917, with the history of gall-bladder disease during one year. There was tenderness in the region of the gall-bladder, but no jaundice, and no history of chills or fever.

*Operation* (December 3, 1917).—On opening the abdomen the gall-bladder presented. Its wall was thickened and it contained a number of medium-sized stones—the ampulla seemed to be filled with a large quantity of very small stones. This part of the gall-bladder was freed easily and a clamp placed upon what was supposed to be the cystic duct and gall-bladder removed from within out. In the dissection a rather dense mass of adhesions was divided after the division of the supposed cystic duct had been made. It then dawned upon him that he had probably excised a portion of the common duct. Examination of the specimen disclosed the fact that the cystic duct was very short and entered the common duct obliquely, and that a section of the common duct three-quarters of an inch in length had been removed. An end-to-end suture was made. The posterior wall of the duct was fairly well approximated, but the anterior part did not come together very well. Drainage tube inserted up to the hepatic duct.

There was a profuse discharge of bile until January 6th—thirty-four days after operation. During the evening of this day the patient had a chill with a slight rise of temperature and vomiting. The next day drainage of bile became very scant, and from that time there has been no discharge of bile. The stools which had been bile-free immediately began to show presence of bile. Appetite and general condition have rapidly improved and temperature has remained normal.

The object in presenting this case is twofold. It illustrates the danger of injury to the common duct if one does not use ordinary care in isolating the cystic duct before placing the clamp. Second, it shows that the common duct regenerates in a short period of time (thirty-four days in this case), provided it is approximated in at least half of its circumference.

DR. HOWARD LILIENTHAL acknowledged having had a somewhat similar case where, in spite of most careful dissection of the gall-bladder, the bile-duct was tied off by mistake for the cystic duct. This was not dis-

covered at the time of operation, but later the patient became markedly jaundiced and died. Since this experience he has always taken the precaution to use a small, easily absorbable ligature in ligating the cystic duct, thus permitting a discharge of bile externally and a possibility of a reestablishment of the canal.

DR. ROBERT T. MORRIS brought up the question as to whether or not it was necessary to suture the cut ends of the common bile-duct, referring to cases in which he had removed a gall-stone impacted in the common duct and left the duct widely open; he considers this method worthy of consideration in cases where it is difficult or well-nigh impossible to suture the cut ends of the duct. He cited a case seen in consultation after removal of the gall-bladder because of the patient being badly jaundiced, and in which an immediate secondary operation disclosed the fact that the operator had ligated a knuckle of the common duct, thus cutting off the duct completely; the ligature was of absorbable catgut and the condition would have remedied itself in time without operation, but at the time of the exploration the patient was suffering from marked obstruction of unknown origin.

DR. WILLY MEYER said that the only cases in which he dissected the gall-bladder, beginning at the cystic duct, were those in which he had wished to test the technical benefit of such a procedure.

He considered it very interesting that careful suture of the posterior half will be sufficient to make the common duct close again after division, except there be such tension that this is impossible; in such a contingency he also would favor the plan that the omentum be turned up against the defect in the duct and thus prevent leakage.

DR. FRANZ TOREK stated that he did not believe it possible to lay down any cast-iron rule for the removal of the gall-bladder, calling attention to those cases in which the cystic duct is very easily accessible, in which instances the tendency would naturally be to take hold of the cystic duct and work from there toward the fundus. For years he has followed the method of taking hold of the cystic duct, getting his finger underneath, and then by blunt dissection with the finger work up to the fundus; by this method he can more easily find the line of cleavage, and he believed there was less hemorrhage from the liver than when removal was in the opposite direction.

DR. HERMANN FISCHER laid stress on the importance in cholecystectomy of careful dissection of the ducts, and cited a recent case showing the importance of this procedure. The patient was a very stout woman suffering from cholelithiasis, and it was found that the hepatic artery ran directly across in front of the cystic duct and might easily have been severed, as the ampulla of the gall-bladder was greatly distended with stones, if he had not adhered to his usual custom of careful dissection of the ducts.

DR. WILLIAM A. DOWNES, in closing, stated that he always made a straight abdominal incision in gall-bladder cases; he has followed the method of removing the gall-bladder from within out in the last sixty or more cases under his care. He considers this much easier in the average case,

## SARCOMA OF THE ETHMOID

because the bleeding is less. By careful splitting of the peritoneal fold and fat the duct can be caught with a sponge-holder and drawn taut, thus exposing the junction with the common duct very quickly and easily. The cystic duct can then be isolated from the vessels, and a clamp placed on the latter. The two layers of peritoneum easily unfold and there is no difficulty in separating it from the bed of the liver. In the case reported he followed this same procedure, but when the common duct which was filled with small stones was pulled forward it resembled the ampulla of the gall-bladder, and, carelessly, not stopping to separate the fold, it was cut through. He considers the method from within out the nicer operative procedure, but he is not prepared to state whether or not it is the safest method of removal.

## SARCOMA OF THE ETHMOID

DR. A. V. MOSCHCOWITZ presented the following two cases, saying that within a period of six months, through the courtesy of colleagues upon the Ophthalmological division of the hospital, there had been referred to him for operation three cases of the rather rare malady of sarcoma of the ethmoid. One of the cases was discharged from the hospital after numerous operations, with metastases in the brain, and is presumably dead. The two cases now presented are of more than passing interest, for the following reasons: First, on account of the rarity of these cases; second, because of the nature of the operation which was undertaken, particularly in Case I; third, because of the splendid cosmetic result obtained in Case I; and, finally, for the reason that both cases promise to be permanently cured.

CASE I.—Rose K., seventeen years of age, was admitted to the ophthalmologic division of the hospital July 24, 1916. Her sole complaint at that time was an exophthalmos of the left eye, which was first noticed eight months before, and which had gradually increased. Examination by Dr. Julius Wolff, Associate Ophthalmologist of the hospital, showed that the left eye protruded in an anteroposterior direction; there was slight limitation of motion on external and internal rotation. There was present a diplopia, on looking to the left, which was due solely to mechanical limitation. No bruit was heard, and nothing abnormal was felt at the orbital margin; there was present, however, a marked resistance to backward pressure of the eyeball. After removing the anterior projecting portion of the middle turbinate with a snare, Dr. Yankauer was able to expose the tumor mass and obtained several specimens for pathological examination, and thus the diagnosis of an "osteosarcoma" was established.

Patient left the hospital temporarily, and was readmitted September 30, 1916. During this interval there was no increase in the symptoms or physical signs.

*Operation* (October 4th, by Dr. Moschcowitz).—An incision was made commencing in the middle of the left eyebrow, and curving at first inward and then downward over the centre of the nose to within a half of an inch from the tip. A quadrilateral flap involving the left

nasal bone and nasal process of the superior maxilla was now sawn out, and attached only by a hinge of periosteum along its external margin. The anterior wall of the frontal sinus was removed from the mesial half. The eye being now held out of the way by retracting it in an outward and downward direction, exposed the mesial and posterior aspect of the orbit. A tumor of bony hardness, situated behind the eyeball, was exposed; it was of the size of a hazel-nut, and was attached to the os planum of the ethmoid. It was excised *in toto* by means of a chisel. The remainder of the ethmoid cells of the left side, in fact, the entire inner wall of the orbit, was also excised. In doing this step of the operation the dura mater was torn over a small area at the inner angle of the frontal sinus. The wound was packed with iodoform gauze, which was led out through the nostril. The osteoperiosteal nasal flap was now replaced and sutured into position with periosteal sutures. The skin was closed with a subcuticular stitch. Perfect primary union followed and patient was discharged nine days after operation. The exophthalmos disappeared very rapidly. The interior of the nose required long after-treatment, owing to a tendency to form granulations.

The patient is presented now, about sixteen months after operation. The only symptom remaining is that of a diplopia of a moderate degree. It is too early to speak of a radical cure, but even at this stage the case may be said to be encouraging.

CASE II.—Sam S., seven years of age, was referred February 14, 1917, by Dr. May. His illness began seven months ago, and it is definitely stated by the mother that he was struck over the right eye, after which trauma the upper lid began to droop. Subsequently the child was treated at the New York Eye and Ear Infirmary, where a diagnosis of an orbital tumor was made, and where two operations for its removal, in October and December, 1916, respectively, were undertaken. After the last operation the eye began to protrude. He also received radium and X-ray treatment. The patient complains of headache and great pain in the eye, which is totally blind since one week. Examination by Dr. Cohn, Adjunct Ophthalmologist of the hospital, showed the following: (1) A high degree of exophthalmos, so that the eye was practically lying upon the cheek; (2) keratitis with lagophthalmos; (3) hypopium, and (4) marked venous congestion of the eyelids. The Röntgen examination was not very satisfactory, as it showed even more destruction of the orbital bones than was found at the operation.

A diagnosis of retro-orbital sarcoma was made and following operation was carried out for its removal, February 16, 1917. A short transverse incision was made at the inner and outer commissure of the eye. Both lids were then dissected free and their conjunctivæ extirpated. The periosteum all around the orbital margin was now incised and elevated from the entire orbit, so that when divided in the depth of the orbit with the scissors, the entire contents could be removed en masse. The inner wall of the orbit, *i.e.*, that part formed by the ethmoid, was involved in the new-growth, and was also extir-

## SARCOMA OF THE ETHMOID

pated, thus opening into the nasal cavity. The skin of the eyelids was turned into the orbit, and held there by pressure. The specimen removed showed it to be composed of the eye and optic nerve, surrounded by orbital fat, and also a large vascular neoplasm, arising by a very broad base from the periosteum covering the ethmoid bone. Microscopic diagnosis, "round-celled sarcoma."

The skin flaps healed on to the denuded orbital bones practically by primary union. Patient left the hospital March 28, 1917. The boy is now, almost a year after operation, in splendid condition. There is thus far not the slightest trace of recurrence.

DR. NATHAN W. GREEN referred to the case of a little boy seen by him a year ago, referred by Dr. W. W. Gilfillan. This child had a sarcoma arising from the horizontal plate in the frontal bone on the right side, the eye was out on the cheek and appeared as big as a billiard ball on account of the chemosis. The pain was so severe that he operated for its relief and he removed all the visible growth, but he left the eye. He went back as far as the circle of Zinn and made the enucleation of the tumor apparently complete. A few months later an identical condition started in the other orbit; this was left alone for a while, as there seemed little hope of benefiting the child, but as the tumor grew it finally pushed the second eye out of position and the pain was so severe that enucleation of this tumor seemed indicated. This was done, as in the first instance, by means of a modified Krönlein's incision. There was an interval of two or three months, then a recurrence in the first eye. Deep X-ray treatment was instituted by Dr. Archibald Evans and the tumor decreased in size a little, but a profound toxæmia from absorption supervened and the little patient died. On microscopical section the tumor was found to be small round-celled sarcoma. On cross-section of the gross specimen the tumor presents a greenish appearance.

DR. WILLY MEYER cited in detail the case of a woman with epithelioma of the nose who neglected her condition until it gradually involved the adjoining tissues. A radical operation was done, removing the entire nose, both eyelids, the eyeball and the greater part of the cheek. Then immediately a large flap was taken from the forehead with the pedicle on the opposite side of the nasal bone, and the entire defect closed, grafting the forehead area, and the result was very satisfactory. At that time Dr. Warbasse, of Brooklyn, worked along these lines of cosmetic repair with papier maché. His interest was solicited for this patient and he constructed a pair of spectacles; to these he attached an artificial nose made of this material and an artificial eye. When this patient was shown to the members of the Surgical Society they were surprised to find her fairly normal appearance due to this ingenious prosthesis.

Dr. Meyer considered it of importance to immediately close the orbit by a skin flap wherever the eyelids have to be removed.

He also called attention to the remarkable results of X-ray treatment



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in some of these cases. Lately he had seen Dr. Pfahler, of Philadelphia, show the photograph of a child with sarcoma of the orbit before and after treatment; before, the eyeball was protruding on the cheek; and after treatment the eyeball was shown to have entirely receded into the orbit and the child had satisfactory vision.

### ACUTE GANGRENOUS PERFORATED DIVERTICULITIS OF THE CÆCUM

DR. ALEXIS V. MOSCHCOWITZ presented a man, forty-four years of age, who was admitted to hospital November 30, 1917. He had never been ill before, beyond an occasional momentary twinge of pain in the right iliac fossa, and which was so trifling that he did not even mention it prior to the operation. His illness began five days before with dull cramp-like pains in the right lower quadrant of the abdomen; there were absolutely no other symptoms. On examination there was found a mass the size of an egg in the right iliac fossa, which was tender on pressure; the lower part of the right rectus showed only a moderate degree of rigidity. At the operation the appendix was found to be perfectly normal. The mass palpated prior to the operation was proven to be a conglomerate mass of epiploic appendages, developed rather more than is normally seen upon the cæcum. One of these epiploic appendages was larger even than the rest, very firm, highly injected, and very brittle. It was entered with great care, and the first object that was encountered was a coprolith, about the size of a bean, lying free in a small abscess cavity; beneath it was a gangrenous area discharging pus and feculent matter. A probe led, at a depth of a little over one inch, into the cæcum. The epiploic appendage was cut off even with the cæcum, and proved to be a false diverticulum, over one inch in length. The hole in the cæcum was sutured in several layers, and was covered with omentum. Drainage with tube and rubber dam. The postoperative course was marred by a pneumonia. The healing of the wound, however, was entirely uneventful, and patient was discharged well in nineteen days.

### RECTUS TRANSPOSITION IN HERNIA

DR. WINFIELD S. SCHLEY read a paper with the above title, for which see page 465, in April number.

DR. L. W. HOTCHKISS stated that he had never been able to persuade himself that the sutured rectus muscle would stay very long against Poupart's ligament. For a good many years after the procedure was proposed by Bloodgood he followed it, but since then had used the method of splitting the anterior sheath of the rectus muscle, using the sheath alone, attaching its edge to Poupart's ligament; he believes more strength is gained by the use of the aponeurosis of the muscle than of the muscle itself, and he sometimes uses in direct inguinal hernia the method proposed by Dr. Downes of including in the grasp of the suture through the aponeurosis the edge of the rectus muscle. He found that the rectus muscle generally pulled out but the aponeurosis did not pull out.

## RECTUS TRANSPOSITION IN HERNIA

DR. ALEXIS V. MOSCHCOWITZ stated that he did not use the method proposed, as he believed it had its percentage of recurrences as well as others. He did not use the method because he believed it to be an unhealthy union between the rectus and Poupart's ligament; before very long the rectus separates, going back to its normal place. He advocated the Andrews method, which he described in detail. He believed the most important thing is the suture of the aponeurosis of the external oblique to Poupart's ligament, because he has convinced himself at secondary operations that even if the external oblique alone is attached to Poupart's ligament the cure in many cases is permanent. He cited a recent case in which he followed this method in a man of seventy-five years with a strangulated hernia; there was no muscle at all, only a good deal of fat, and so he was compelled to rely entirely upon the aponeurosis of the external oblique muscle.

DR. WILLY MEYER said that it seemed to him the strength of Dr. Moschcowitz's suture of the internal portion of the external oblique to Poupart's ligament lay in the fact that he put over it the lower portion of the external portion of the external oblique. He cited a case of recurring hernia in a female in which he succeeded in getting a good repair, by means of this overlapping tissue-flap suture, the patient afterward becoming pregnant, and up to date has developed no further signs of a recurrence.

DR. SEWARD ERDMAN stated that in a paper recently read before the Surgical Society he had reviewed the results in a series of herniotomies performed on the Second Surgical Division of the New York Hospital. The recurrences after all varieties of operation for direct hernia were between 15 and 20 per cent., up to date. Recurrences of direct hernia after rectus transposition were also between 15 and 20 per cent., thus revealing no especial advantage for this procedure. Statistics of recurrences after transposition of the rectus in oblique hernia are of little value, because in oblique hernia such transposition is practically never indicated; therefore it cannot be claimed that the results are influenced by such transposition.

DR. FRANZ TOREK called attention to the fact that the internal oblique and the transversalis sometimes will be inserted low down near the lower end of the rectus fascia, at other times much higher. Where they do not go well down, the rectus must be depended on for the closure of the lowest part of the hernial opening. He brings the rectus with its fascia over to Poupart's ligament without splitting the fascia, which requires a good deal of tension sometimes. Two points are that the suture must be carried way down to the lowest portion, down to the very insertion of Poupart's ligament, so close that in the last suture the needle will almost scrape the pubis as it goes through Poupart's ligament, otherwise there will be a possibility of a direct hernia. The next point is to use sutures that are dependable where there is much tension; he uses silver wire, in such instances, for the lowest suture, sometimes for the lowest two sutures. Dr. Torek stated that since his report of his series of cases operated according to his own method, as published in 1912, he had found no recurrences up to date.

DR. WILLIAM A. DOWNES stated that there were many more recurrences in hernia cases than was generally supposed. In replying to a letter from the Surgeon-General's office as to further information on the status of hernia in the enlisted men, Dr. Downes made a statement that he believed direct hernia will show from 15 to 20 per cent. of recurrences if followed long enough. This is based on his own experience. He looked up 480 cases done in four years at St. Luke's Hospital, of which 35 or 40 per cent. responded; of these there were 12 or 15 recurrences in the direct cases and these statistics are based on personal examinations of the patient. Any statistics based on written reports are unreliable; two patients wrote that they were perfectly well but on routine examination were found to have recurrences. In the majority of cases sufficient removal of the hernial sac is not done. As far as the use of the rectus muscle is concerned he suggests a compromise, using both the aponeurosis and the muscle.

DR. W. S. SCHLEY emphasized the necessity of relief of tension in utilizing the rectus muscle, and suggested the wide opening of the sheath of the muscle and the introduction of at least four sutures, then insisting upon the patient remaining in bed for eighteen days, thus saving a month in convalescence and giving a good primary union. If the patient is allowed up earlier so that the sutures are not absorbed and act as a foreign body, good results cannot be expected. If the operation as he recommends is done, he believes the rectus transposition gives the best result so far obtained. In all cases so far followed by him there have been no recurrences.

#### PREVENTION OF PERMANENT BRONCHIAL FISTULÆ

DR. HOWARD LILIENTHAL presented a paper with the above title, for which see page 538.

DR. MARTIN W. WARE (by invitation) stated that he had often witnessed the operations of Dr. Lilienthal, and he could substantiate his statement, that in all these cases the fistula in the bronchus was far from the surface with an intervening cavity where granulation could occur. An important point is that all of these cases were not amenable to the methods advocated where the tissue is pliable; here the tissue was rotten and the mass ligature was applied in a great many instances. He called attention to the channel drainage which may bring about a more direct connection between the bronchus and the surface of the body, and thus favor fistula formation, since the mucous membrane and skin readily bridge over and line the tract with epithelium. A like condition prevails in all intestinal fistula leading very directly to hollow viscera, whereas when the tract is indirect or tortuous and of great length any intervening area of granulation by its larger amount may by its growth obviate fistula formation. The tube drainage in these cases by a buttonhole far removed from the line of incision tends to create long intermediate areas of granulation tissue between the bronchus and the skin favorable to closure.

## HYPOGLOSSAL-FASCIAL ANASTOMOSIS

### HYPOGLOSSAL-FACIAL ANASTOMOSIS FOR FACIAL PARALYSIS

DR. HERMANN FISCHER presented screen pictures of a man who, on September 20, 1915, thoughtlessly expressed the contents of a pimple on right side of neck below angle of jaw. A few days later evidence of infection appeared and seemingly matured as a small carbuncle. This was widely incised under anaesthesia on September 29th. Practically no pus or other product of disintegration was obtained. A few days later two small masses resembling carbuncular core were discharged.

The swelling persisted, gradually extending up and about the ear until October 19th, one month after operation, when a total facial paralysis of the right side supervened, which, from the parts involved, was evidently of the infranuclear type. From this time the local condition took on a severely malignant type, rapidly extending over the side of the head from the jaw back to the median line of the neck posteriorly and from the shoulder to the zygomatic line, almost submerging the pinna. The skin assumed a dusky red similar to that of malignant erysipelas. This swelling was accompanied by excruciating pain which radiated over the side of head and neck, not being localized. The neck was immobilized by it and felt as if in a splint. Later the swollen tissues became somewhat doughy and pitted on pressure in the region below and in front of the ear. During this time deafness of the right ear developed and advanced to completeness. Classic symptoms of mastoiditis were absent and an exploratory paracentesis tympani failed to discover more than a congested condition of the middle ear, yielding but a few drops of bloody serum. There was profound systemic infection, severe arthritis of the left shoulder and recurrences of severe myalgia in various parts of the body.

Coincident with this rapid extension of the local trouble, the swelling at the site of the infection subsided. The patient experienced a constant sense of pressure deep in front of the mastoid process as though a wedge had been forced deeply internal and anterior to that structure. Later it was thought that deep fluctuation was detected over this area just posterior to the ramus of the jaw. An exploratory incision was made without illuminating the situation. This incision failed to heal, however, and resulted in a small slightly discharging sinus. Conditions gradually improved so that the patient was about the house by November 25th. He still sustained a pronounced deafness, the "wedge-like" sensation persisted and there was no abatement of the paralysis. On December 9th a few drops of pus were found in the external auditory canal of the affected side. The ear was examined by Dr. Case, of Elmira, N. Y., and a small polyp was found arising from the floor of the canal, just exterior to the membrana tympani. When this was snared out, a small opening was found. This opening led into a channel following the line of the facial canal, in which the probe detected necrosed bone. This channel was found to be continuous with that of the sinus before mentioned.



On the following day the mastoid was opened and from a large necrotic cavity were removed a number of loose sequestra. Attached to the whole length of the largest of these, three-eighths inch in length, was a macerated section of the facial nerve with frayed ends.

The operation revealed the most unusual condition of a virulently septic process, ascending through the stylomastoid foramen, causing extensive necrosis of the bone, surrounding the facial nerve and finally destruction of the nerve itself. Paralysis occurred in the fourth week. The operation was done when the total paralysis had lasted for eight weeks. For the relief of this paralysis an hypoglossal-facial nerve anastomosis was done August 29, 1916.

Technic: Skin incision two fingers' breadth below ramus of mandible from lowest point of mastoid process to midline below chin. The line of incision corresponds to the course of the digastric muscle. The skin flap is dissected up from the underlying tissues until the lower part of the cheek with parotis is laid bare. The hypoglossal nerve is dissected out and cut off where it disappears under the mylohyoid muscle. Now the trunk of the facial muscle is looked for below and behind the parotid gland at the point where it leaves the stylomastoid foramen. To accomplish this, the parotid gland must be carefully raised from its bed, without interfering with the numerous branches in which the facial nerve splits up. There was quite some difficulty in finding the nerve on account of the dense and hard scar tissue which was caused by the previous operations. After the nerve was laid bare just below the external auditory meatus, it was followed up to the point where it emerges from the stylomastoid foramen. It was cut across close to the foramen and its peripheral end was sutured to the central stump of the hypoglossal nerve. In handling the nerves, extreme caution was exercised to grasp the perineurium only by means of small mouse-toothed forceps. Three sutures of finest silk, catching the perineurium of the nerves, were used to perfect the anastomosis. The parotid gland was replaced over the nerve and the wound closed. There was quite some annoying hemorrhage from the bulbus of the jugular vein, which had been nicked inadvertently while dissecting the scar-tissue. It was finally controlled by suture of the vein.

The wound healed by primary union and the patient left the hospital on the sixth day after the operation. Following the operation there was much induration of the tissues over the ramus of the jaw and along the line of incision which persisted for some months. There was also numbness and tingling sensation, intense upon touch throughout the indurated area and the pinna. The patient experienced great difficulty in swallowing for several weeks after the operation. At first this trouble was extremely annoying, accomplished with great difficulty and attended by choking with almost every attempt, no matter what the nature of the food. Soon it was found that if a bolus not too large or too small was formed it could be grasped by the muscles—a larger being refused and the small not affording



## TRANSPLANT ON HAND AFTER CARCINOMA

sufficient bulk. It also required some time to educate the tongue to deliver masticated food to the proper points for swallowing. Both conditions were helped by the generous use of fluid "to wash" food down. Speech has not been materially disturbed.

The patient is conscious of a little more difficulty in forming words containing the linguals, but on the whole, this phase of the postoperative results is not worthy of a place in the factors to be considered.

DR. A. S. TAYLOR considered the result in this case was most surprisingly good. Most of the men who have written on this subject say that one should completely divide the hypoglossal transversely to get end-to-end suture with the facial. In a series of 15 or 16 cases published in 1905, in every case Dr. Taylor used simply the lateral implantation of the facial into a longitudinal split in the hypoglossal. The advantage in this method is that while there is a temporary disturbance of the hypoglossal function, after a couple of months there is complete return of function to the hypoglossal with a satisfactory return in the facial. If one takes these cases when they first begin to show return of power in the facial nerve, and prescribes motions and exercises involving hyperactivity in the muscles controlled by the hypoglossal, one can increase the rapidity of return of power in the facial muscles, because, by overstimulating, nervous energy will overflow from the hypoglossal into the facial with return of power in that area.

*Stated Meeting, Held February 13, 1918*

The Vice-President, DR. WILLIAM A. DOWNES, in the Chair

## TRANSPLANT ON HAND AFTER OPERATION FOR CARCINOMA

DR. EDWARD M. FOOTE presented a man aged thirty-one. When eighteen years of age, a "wart" appeared in the web between the index and middle fingers of the left hand. In the following twelve years he had many salves applied; treatments by electricity; more than twenty-four X-ray treatments, and several minor operations, including one excision and skin-grafting. Sometimes the ulcer healed, but always reappeared in a few months or less.

February 5, 1917: Doctor Foote excised the tumor freely, carrying the dissection well down between the fingers to the muscles, and stitched into the wound a flap from the abdomen. The pedicle was partly divided on the third day, and completely divided on the eleventh day. Healing was uneventful. Four months later, when atrophy was complete, some excess fat was removed from beneath the transplant. Doctor Jessup, who examined the tumor, reported it to be a prickle-cell epithelioma.

At the present time there is no sign of recurrence. The skin of the transplant has gradually assumed somewhat the appearance of the surrounding skin. Tactile sensation has appeared in a part of the transplant, and the

sense of pain on pinching or on pulling the fine hairs is more widely distributed over the transplanted area.

## LUNG ABSCESS

DR. NATHAN W. GREEN presented a man, thirty-two years of age, who was admitted to the City Hospital to the service of Dr. E. P. Shelby, December 4, 1917. The diagnosis on admission was bronchitis. At that time he was suffering from cough and a profuse expectoration with a fetid odor and a pain in his right chest. On January 2, 1918, two ribs were partially resected subperiosteally. The pleura was found thickened and a needle introduced through this thickened pleura withdrew air. An opening was made along by this needle and a cavity encountered one inch anterior to the pleura. This cavity would contain about an ounce of fluid. It contained foul-smelling pus. A large rubber tube was introduced into it and drainage established posteriorly. The temperature was normal on the second day after the operation and the tube was left in place two weeks, then removed a few days, and again inserted for six days more, when it was removed altogether. The quantity of expectoration rapidly diminished, and except for an afternoon temperature coming on two weeks after operation and lasting several days, he had an uninterrupted convalescence. The fetid odor from the breath has now cleared up and there is practically no expectoration (February 13, 1918).

DR. WILLY MEYER called attention to the statement that Doctor Green withdrew air with the syringe in his aspiration, and in this connection he detailed the case of a patient under his own observation who had been coughing pus for quite a long time, where he could find with the needle no pus in the chest, but where on aspiration he withdrew air. He considers the withdrawal of air from the lung as an important symptom of having entered a cavity, provided a reliable record-syringe is used.

He considered the question of whether to aspirate before operation, and suggested where possible having a bronchoscopic examination made for the detection of the exact location of the pus. He personally feels more and more inclined to advocate preoperative aspiration for preoperative diagnostic purposes. He referred to a recent case in which he attempted to localize the abscess, besides the usual clinical methods, by bronchoscopy and the X-rays, and in which case he believes had he inserted the needle he would have been led to enter the cavity from the back of the patient rather than from the front and thus had a much easier operation. Another question he brought forward was the method of incising the lung, with the knife or with the cautery. He always uses the Paquelin cautery if deeper portions of the lung have to be entered.

DR. ROBERT T. MORRIS stated that it was of interest to decide what to do upon opening and finding the pleura not involved. He had seen Schede open the chest for empyema in a case in which the pleura was found to be perfectly normal but where the diaphragm was bulging—a case of subdiaphragmatic

#### ABSCESS OF LIVER DISCHARGING THROUGH BRONCHI

abscess; he closed the chest wound, and then entered the abdomen below the diaphragm. He referred to a recent case under his observation in which the X-rays showed the diaphragm to be highly arched but which later turned out to be a liver abscess. The question of lung abscess had been entertained until the radiograph disclosed the real situation.

DR. N. W. GREEN, in closing, stated that in the case reported the lung was adherent to the parietal pleura and the puncture was made through this so there was no free chest cavity to contaminate. The puncture was done at the time of operation. He stated that he sometimes used the knife, then scissors, first closed when introduced, then opened, and he never feared bleeding to any extent because the puncture is made at the periphery of the lung where the vessels are small, and any bleeding which might occur he believed could be controlled by packing.

#### ABSCESS OF LIVER DISCHARGING THROUGH BRONCHI

DR. N. W. GREEN presented a case of a man who was admitted to the surgical service of the City Hospital, October 5, 1917, complaining of weakness, anorexia and loss of weight. A diagnosis of empyema was made and on October 9, 1917, he was operated on for this condition, resecting the eighth rib. He did not improve rapidly, but rather continued to fail. Upon rounds it was observed that he was expectorating a yellow sputum which appeared strongly bile stained. There was no characteristic odor to it. After studying the case for some time, the diagnosis of a fistulous tract connected with the liver was made by Doctor Green. In other words, that a liver abscess was now being discharged through the trachea. This was confirmed by Dr. E. P. Shelby, attending physician. An operation was performed on November 24, 1917, by Doctor Green, resecting part of the ninth rib and opening the old empyema cavity. The examining finger detected the outline of this cavity together with a smaller cavity at the apex of the empyema cavity, which in turn communicated with a bronchus. In the other direction a small opening about the size of a slate pencil was detected on the dome of the diaphragm, which led through the diaphragm. An artery clamp was introduced closed through this hole and the opening was stretched to finally admit the finger. The finger then detected a large cavity the size of a small orange underneath the diaphragm and within the substance of the liver. The opening was now made larger by cutting it directly outward through the diaphragm with a knife and two sets of large double drainage tubes introduced—one set into the liver cavity and one into the combined lung abscess-empyema cavity. The discharge through these tubes was at first profuse. The discharge through his trachea rapidly diminished. After a few weeks both sets of tubes were removed and the discharge through the external sinus has now ceased. The expectoration has ceased and the patient has gained about twenty pounds. An interesting point in his case is the fact that, owing to the presence of bile, the fetid odor which is so frequent with lung abscesses was absent.

## DEPRESSED FRACTURE OF SKULL OVER SPEECH CENTRE

DR. N. W. GREEN presented a man, aged twenty-five years, who was admitted to the Surgical Service of the City Hospital, January 1, 1918, with a story that he had been celebrating the New Year's Eve, the night before, with some friends. Upon admission he presented the following conditions: He showed a lacerated wound of the scalp where he had been struck by some blunt object. There was ecchymosis of the left eye and epistaxis. The right side of his face was paralyzed. He was unable to speak, although he seemed to understand what we said to him and he could smile and make vocal noises. Upon examination a depression in the skull was made out at the anterior and lower end of the scalp wound which was over the left temple. This depression was about an inch and a half long and half an inch wide.

An operation to relieve the depression was performed at once under general anæsthesia and a depressed portion of bone one and a half inches long and one-half to three-quarters of an inch wide was removed. The dura was opened and blood clots together with lacerated brain were extruded. The dura was again closed and the scalp wound closed completely, except for a small drain. One week after the operation the patient was again talking, but in a hesitating manner. His speech has continued to improve to the present time.

## MORPHŒA OR SCLERODERMA

DR. WILLIAM B. COLEY said that while the etiology of morphœa is extremely obscure, there is some evidence to show that it has some relation to changes in the thyroid gland. Robinson, in a "Report of a Case of Scleroderma of the Skin" (*American Journal of the Medical Sciences*, November, 1917, page 657), states that the average occurrence of idiopathic, atrophic dermatitides taken from five large skin clinics in this country and abroad is 1 in every 2580 cases and he believes that every case should be reported in order to add to the general knowledge of a rare condition. It was first described by Thirlial in 1845, under the name of "ichthyosis," and later in 1854 by Addison. Erasmus Wilson termed it morphœa, when the condition is that of a circumscribed scleroderma. Osler, who perhaps has given the best description of the condition, defines it as "a nutritional disturbance of the skin, patchy or diffuse, leading to induration and atrophy; usually considered to be a trophoneurosis, the characteristic lesions being areas of skin which are waxy and œdematous-looking, surrounded by a violaceous areola, and which gradually become brown, tense, hard, and hide-bound, with increase in collagenous material."

In 68 cases analyzed by Robinson, in 60 or 88 per cent. the hands were affected; 19 per cent. showed changes in the thyroid. Because it was believed that this condition was due to a thyroid deficiency, thyroid extract was given, resulting in improvement in 2 cases, no improvement in 4, and no change noted in 5 cases.



## MORPHCEA OR SCLERODERMA

In Robinson's series, the thyroid was found unchanged in 12 cases, atrophic in 3, and hypertrophic in 2. Syphilis was negative in 13 cases and positive in 9; Raynaud's disease was present in 4 cases, Addison's disease in 1, tuberculosis in 2, and diabetes in 2. Robinson states that it has quite generally been accepted that scleroderma is a trophoneurosis and due probably to a disturbance of the thyroid function. He adds, "The thyroid is not the only gland of internal secretion that is affected. Roux found sclerotic changes in the hypophysis, and believed it to be a functional disturbance of that gland. Changes in the adrenals have been described. Dupre, Kahn, Rosch and others believed in a pluriglandular pathogenesis. Falta and Cas-siver believe that in scleroderma the glands of internal secretion are affected, but the process is not primary in the ductless glandular system. Since all the glands of internal secretion may be affected in those having scleroderma, and since they are all probably influenced by the vegetative nervous system, it is possible that a disturbance of this nervous system may be the primary cause, though this has certainly not been proven. Osler, Grasset, and Dehu, from the changes in the nervous system, the perversion of nutrition, analogous to that of myxoedema, together with Jeanselme, Singer, Hektoen, Leredde, Thomas and others, regarded the cause as that of a thyroid deficiency."

Doctor Coley presented a man, aged eighteen years. Family history negative. Present trouble began eight years ago in the nature of a callous formation on the hands, which areas became very tender. Two to three weeks later the same condition appeared over the soles of the feet, and in the course of several months the latter also became tender. During the early stages of the disease the patient would have periods of remission when the trouble almost completely disappeared, but these intervals later became shorter and shorter until during the last few years the progress of the disease had been almost continuous and the patient became practically a complete invalid. He was referred to Doctor Coley by Dr. Henry McMahon Painter in November, 1917. A letter from Dr. Jos. A. Dillon, of New York, who had had the case more or less under his supervision, states:

On February 17, 1909, the patient came under treatment for callositis of the feet and tips of fingers. The usual course of events has been that the hard epidermis would come away and leave the underlying parts in good condition. He would at first be free from the trouble for many months, but there was inevitably a recurrence and the intervals between attacks shorter until it has been almost continuous. The lesions have increased considerably in size. Wassermann test negative.

All kinds of drug treatment have been used; arsenic, mercury, iron, iodides internally, and externally green soap, mercurial ointments, salicylic collodion, formaldehyde—all without pronounced effect. He was sent to the Skin and Cancer Hospital in 1915 in the hope that Röntgen ray or radium treatment would be tried, but as he seemed to do well on salicylic ointment he was discharged after two weeks' treatment. He has been shown to physicians at Society meetings, but no one has made a suggestion that was helpful. He has not been at the Neurological Institute.



The blood examination, made November 3, 1917, soon after his admission to the Memorial Hospital, showed: Red blood-cells, 4,400,000; hæmoglobin, 87; lymphocytes, 32 per cent.; white blood-cells, 14,400; polymorphonuclears, 67 per cent.; eosinophiles, 1 per cent.

At the time of his entrance on October 26, 1917, the palmar surface of both his hands and feet were completely covered with enormously thickened patches of callus-like tissue which somewhat resembled keloid. The fingers and toes were markedly flexed and it was impossible for him to extend them; the patient was unable to walk or to use his hands in any way. The hands and feet were so sensitive that the slightest touch caused severe pain.

*Pathological Report* (November 1, 1917).—Hyperkeratosis. Tumor-like hyperplasia of intermediate hornifying epithelium. Hypertrophy and elongation of rete pegs. Plasma cell infiltration of cutis.

*X-ray Findings* (November 3, 1917).—Bones of hands show marked osteoporosis throughout.

After looking up the literature on the subject, Doctor Coley decided to try the suggestion of Dr. A. S. Robinson, of Cleveland, and put the patient upon the thyroid gland extract, 6 grains 3 times a day. The following results can best be noted by an inspection of Figs. 1-6.

In Fig. 1, taken November 16, 1917, the areas of cornification show a marked tendency to break up into separate island or patches with fissures and cracks between. In many places the horny layers of tissue are beginning to peel off. The power of extending fingers is much greater than when he entered the hospital.

Fig. 2, taken December 1, 1917, shows the condition of the hands to have cleared up remarkably, only one large patch remaining on one hand; extension almost complete.

Fig. 3, taken December 22, 1917, shows the condition of the hands almost normal. While the patient has had periods of remission during the last eight years, as has been stated, during the last year the progress of the disease has been almost continuous, and at no period during the whole eight years has there been such complete disappearance of the lesions as at present; therefore, it would seem probable that the treatment with the thyroid gland extract has been largely responsible for the improvement in the condition.

*Pathological Report No. 2* (January 19, 1918).—Report on microscopical examination of case of D., by Dr. Ewing:

In the material received the thickness of the Malpighian layer is between 30 and 50 millimetres, to which an exaggeration of all the strata contributes, while the derma is also thickened and cellular.

In the derma there is a uniform infiltration by round-cells, mostly lymphocytes, while the capillaries are very numerous and much congested. The sweat-glands are normal, and no hair follicles are present.

The papillæ of the epidermal layer are very much elongated and project as narrow cords deeply into the derma. In the basal layer of cells there are numerous mitoses.

At the edges of the lesion the Malpighian layer ends in a broad zona granulosa, which is immediately succeeded by a very thick deposit of nearly homogeneous keratin layer, but in the main portions of the lesion the process of keratosis is interrupted by a broad layer of rather small eosin staining cells which are so abundant as to suggest an approach to a tumor process. These eosin staining cells contain relatively large and sometimes multiple nuclei; the

FIG. 1.



FIG. 2.



FIG. 3.



FIG. 1.—Before treatment.  
FIG. 2.—After one month's treatment.  
FIG. 3.—After two months' treatment.



FIG. 5.—Microscopic section (low power).

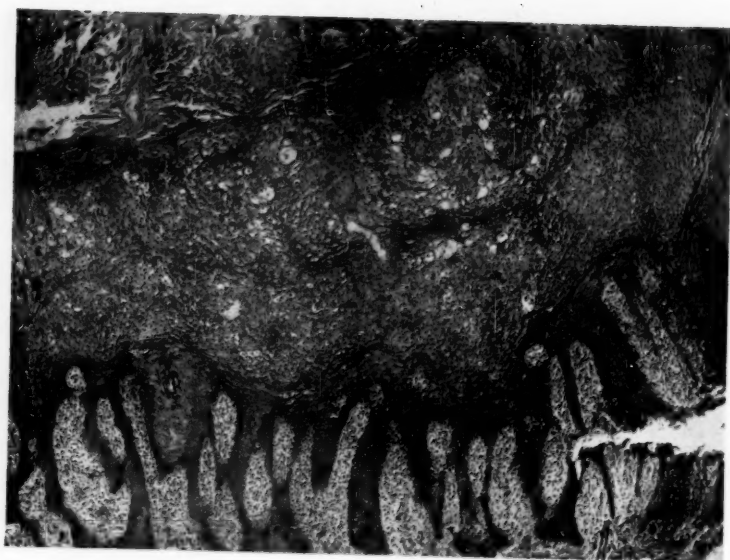


FIG. 4.—Microscopic section (low power).



FIG. 6.—Microscopic section (high power).



FIG. 7.—Case of extensive scleroderma in the later stages.



## MORPHEA OR SCLERODERMA

cells bodies are partly homogeneous and keratinized, and many cells show hydropic vacuoles. In the outer half of this peculiar layer there is hemorrhage, and the cells are looser, many of them forming indistinct small pearls.

The outer layers of the lesion are composed of a thick mass of keratinized material, which is dense, structureless, lamellated, acid and basic staining in different points, and sometimes broken by pockets of semifluid material.

The main histological feature of the process is an excessive and abnormal keratinization, marked by a remarkable excess of partly keratinized cells which form a thick layer beyond the zona granulosa.

The process may be interpreted as a nutritional disorder, affecting the function of keratin formation. The only mitotic cell proliferation is found in the basal layer of the papillae.

(Signed) J. EWING.

Examination January 25, 1918, shows the condition the same as at the time of the last note; the hands are entirely normal, the patient is able to walk, and there is no evidence of any return of the trouble.

Doctor Coley believes it is only fair to state that the patient has had periods of remission and of partial disappearance of the lesions before, especially in the early stages of the disease, but the disappearance has never been so complete nor the period of freedom from trouble so prolonged as at present, and Doctor Coley thinks it probable that the thyroid extract had some part in the favorable result.

DR. ROYAL WHITMAN said that he had seen a number of cases of scleroderma, but that they were of a different type from that presented. The lesion was extensive and deep seated, the affected skin changing to an indurated substance, resembling somewhat the scar of a burn, which contracting distorted the affected part. In one case, seen recently, the disease was very extensive, involving all the extremities, causing distortion and ankylosis of the joints with large areas of ulceration.

DR. JOHN ROGERS thought it interesting to figure out how the thyroid extract affected the condition, stating there was probably not an organ in the body which had not been treated by the use of thyroid. From the experiments he had been able to follow, the only material demonstrable action in the thyroid acts through the vagus and not through the sympathetic system. He believed the condition exhibited might have some relation to a trophoneurosis, and this might explain the action of the thyroid feeding through the autonomic fibres which are known to supply at least the sweat-glands.

DR. WILLIAM B. COLEY, in closing, stated that he believed Dr. Whitman's case was a variety of the same general type of progressive scleroderma. Characteristic lesions increase with remissions in the earlier stages. Ulcerations occur in 50 per cent., according to Robinson. The supposition is that it is a trophic neurosis due to thyroid deficiency. He stated that the treatment so far had been entirely empirical; actual disturbances in the thyroid had been noted in 19 per cent. in one collection of cases, and even in larger percentage in another collection, so that now thyroid has been used in a considerable number of cases with marked improvement in some. With regard to the condition being of congenital origin it is not so far regarded

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in this light. Syphilis plays a very small part, being found negative in 18 cases and positive in 9. The etiology is acceded to be obscure.

Doctor Coley added that it is possible that the improvement in his own case was due to a natural remission of the disease rather than to a result of the thyroid treatment, although the history of the case would make this improbable.

### REPAIR OF COMPLETE RECTO-VAGINAL LACERATION

DR. IRVING S. HAYNES read a paper with the above title, for which see page 501.

### FRACTURE OF THE CERVICAL SPINE PRODUCING BROWN-SÉQUARD SYNDROME

DR. DEWITT STETTEN presented a man who was discharged from the Army because of his present condition, which was caused by his diving into a shallow tank on June 9, 1917. He struck his head, was unconscious for a few days, and was found to be paralyzed on his left side. He was regarded at first as a case of cranial injury with cerebral hemiplegia. Later examination showed in addition to the left homolateral corticospinal hemiplegia a contralateral analgesia and thermoanæsthesia of the right leg and side to above the nipple line, *i.e.*, a Brown-Séquard paralysis due to a hemi-lesion of the left side of the lower cervical cord. The radiographic examination shows a compression fracture of the fourth, fifth and sixth cervical vertebræ with backward dislocation of the bodies.

## CORRESPONDENCE

### TORSION AND STRANGULATION OF A PYOSALPINX

EDITOR ANNALS OF SURGERY:

The twisting of a pyosalpinx to a sufficient extent to cause strangulation seems to be a rare accident; and a cursory examination of the literature did not reveal a reported case. In the very full analysis of seven hundred cases made by Goth<sup>1</sup> no mention is made of the occurrence of this condition. Hence it would seem that the adhesions which usually occur in most of these cases are sufficient to prevent the peristaltic movements of the intestine and exercise from rotating them. In view of these considerations I beg to report the following case:

A girl, aged twenty years, white, was admitted to the hospital of the University of Kansas on September 19, 1917, complaining of pain throughout the abdomen with severe cramp-like pain on the right side. She states that she was perfectly well until five days previous to her admission to the hospital. At that time she began to have some pain of an aching character to the right of the umbilicus. The pain was the first of the kind that she had ever experienced; and at first it did not prevent her eating her meals regularly or continuing sewing on the machine, as was her habit. This pain continued two days; then on the third day she felt perfectly well. About midnight of the third day she awoke with a severe cramping pain in right side of abdomen. She was badly nauseated, and vomited several times. The following day she felt a little easier, but had several attacks of a severe cramping pain which was always located on the right side. At the time of admission to the hospital she felt less pain. She was a well-developed young woman who did not present an appearance of being particularly sick; pulse 76 and of good quality; temperature 99.6°. She placed her hand to the right side occasionally and preferred to lie with the legs flexed; though she did not seem to be in pain. The heart and lungs were normal. The abdomen showed some rigidity and tenderness, especially over the right lower quadrant, where an indistinct mass about the size of an egg could be palpated. She had a leukocytosis of 15,000, with 76 per cent. of polymorphonuclear leucocytes. A vaginal examination revealed a small cervix and uterus in normal position. There was some resistance on both sides, but the patient was so tender that a satisfactory pelvic examination could not be made. She was menstruating profusely and said that she also menstruated profusely three weeks ago.

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<sup>1</sup>Dr. Gayos Goth: Klinische Studie über sieben hundert Fälle von entzündlichen adnextumoren. Archiv für Gynekologie, Bd. 92.

On September 20, 1917, under ether anæsthesia, a median incision four inches long was made. A quantity of bloody serum escaped from the abdominal cavity. The mass was found to be attached to the uterus and was apparently a pyosalpinx which had been turned one and a half revolutions towards the right and completely strangulated, being black and œdematous. There were no adhesions. The mass was removed. On the left side there was a mass of similar size, with very light adhesions and not strangulated. It also was removed. There were some slight fibrin deposits on the small intestines. The appendix was looked for casually, but as the cæcum was not seen and there seemed to be no evidence of a pathological appendiceal condition, the search was not continued.

The recovery was uneventful and the incision healed by primary union. The patient was discharged on October 4, 1917.

MERVIN T. SUDLER, M.D.,

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### ON TUMORS OF THE SALIVARY GLANDS

#### EDITOR ANNALS OF SURGERY:

In the ANNALS OF SURGERY for January, 1911 (lxvii, 67), there appears a paper by Drs. J. Forman and J. H. Warren on "The So-called Mixed Tumors of the Salivary Glands, with a Possible Explanation of the Morphological Behavior of the Tumor Cells." It is based on a study of seven cases, the "stroma" of three of which contain cartilage. The "parenchyma" presents the usual appearance of gland-like structures, of interlacing tubules, and of flattening of the cells, whose resemblance to endothelium is striking in places. No evidence, however, was found which showed that they are of endothelial origin. The last case closely simulates a "histoid carcinoma of the epidermoid variety." It is, in other words, a squamous-celled carcinoma.

The authors point out that, in order to explain the presence of "parenchyma" and "stroma" in these tumors, embryonic inclusions of meso- and of epiblast have been postulated by different writers on the subject. They "are of opinion that a simpler explanation of these new-growths is at hand, if one takes into consideration that the derivation of some of the head cartilages can be ascribed to epithelium." They next review some of the papers on this subject, and quite reasonably conclude that, if cartilage arises in this way in the lower vertebrates, "there is a possibility, if not a probability, that there is in the head and brachial region of the human embryo mesenchyme which has been derived from ectoderm. Later this may differentiate into cartilage," etc. "Inclusion or misplacement of this ectodermal mesenchyme gives rise to the so-called mixed tumors of the salivary glands."

I am myself a firm believer in the mixed origin of the mesenchyme, and have read Forman and Warren's paper with much appreciation. The development of the cranial and branchial regions is a highly complicated one,

and the evidence that these writers have collected from the literature is not absolutely convincing. I therefore look forward with much interest to Landacre and Warren's researches on the subject, which are shortly to appear. The reason why the evidence is not conclusive is not far to seek. The mesenchyme cells that are budded off from the epidermis are identical in structure with those derived from other sources. As the cartilage does not become recognizable as such until later, and as it is not situated immediately under the skin, it is difficult, if not impossible, to demonstrate beyond question the ultimate origin of its cells. To V. Szily<sup>6</sup> belongs the credit of having proved that parts of the skeletal system actually are formed by the epiblast. He showed that, in the tail-fin of the trout, some of the superficial bones arise within the deeper layers of the epidermis, and that they are at first completely surrounded by *epithelial* osteoblasts. The same author<sup>6</sup> has demonstrated the origin of the *sphincter pupillæ* from the epithelium of the iris. Heerfordt<sup>1</sup> had previously proved the same derivation for the *dilatator pupillæ*. These three papers, if, as a morbid anatomist, I am qualified to judge, establish beyond all manner of doubt that mesenchymal tissues can and do come from the epiblast. They greatly strengthen the corresponding work done on the cranial and branchial cartilages. I may add that there is a considerable amount of evidence that the cutis is derived from the epidermis. Retterer,<sup>4</sup> to take but one instance, believes that this takes place in man throughout life.

These researches are of fundamental importance. If correct, they upset the doctrine of the specificity of the germinal layers, a doctrine which has been believed in and taught as a first principle by all the most eminent authorities in every branch of biological science. They should therefore not be taken lightly, but be carefully weighed before being accepted. I, for one, believe that their correctness has been established by the three instances referred to above, and that we are therefore justified in using them to explain other conditions, an instance of which are the mixed tumors of the salivary glands. In this I am in perfect agreement with Forman and Warren. I must, however, deplore that they apparently did not trouble to acquire a thorough knowledge of the literature of this subject. Had they done so, the writings of Krompecher, whose name is not once mentioned in their paper, could not possibly have escaped their attention. In two papers,<sup>2, 3</sup> one of which is a continuation of the other, and which appeared ten years ago in *Ziegler's Beitræge* (which surely are read in America?) his views are, briefly, expressed thus:

Salivary tumors are basal-celled carcinomata, a group which includes rodent ulcer. They are epi- and hypoblastic according to their situation. The former only concern us here. In the case of the salivary tumors it is impossible to prove their connection with normal epithelium, but their true nature is easily demonstrable by a study of the comparative morphology of basal-celled carcinomata in general. There is no sharp line of separation between epithelium and connective tissue; the cells of the former become



## CORRESPONDENCE

stellate, acquire processes, and pass into the stroma, from whose corpuscles they cannot be distinguished. In fact, *they become connective-tissue cells*. He next describes all the pathological conditions in which he believes this transformation to occur, and goes into the zoological and embryological literature. He does not omit the development of cartilage from epiblast, but, perhaps for the same reasons that I have given, he lays no stress on it.

Krompecher thus comes to the conclusion that, in basal-celled carcinoma, including the tumors of the salivary glands, the connective tissue is budded off from the epithelium, *i.e.*, it is ectodermal mesenchyme. Forman and Warren arrive at precisely the same conclusion, but have reached it by a different way. The former argues from the appearances which can be seen in a large number of actual cases, and the latter from the analogy of the development of the cranial cartilages in the lower animals. The weakness of Krompecher's evidence, when applied to salivary tumors, lies in the impossibility of proving that they arise in the epithelium of the gland. His contention is greatly strengthened by their very close similarity to certain epidermal new-growths of the head, a fact that I can corroborate from my own experience. Forman and Warren's weakness lies in the fact that, granted that the epiblastic origin of the cranial cartilages has been satisfactorily proved for the lower vertebrates, it has not been so proved for man or is ever, as they themselves admit, likely to be. Both sets of writers can therefore claim merely to have advanced a working hypothesis based on analogy.

My excuse for writing these lines is made by the importance of the subject. Not only do these researches shake the very foundations of biologic doctrine, but, to take an instance nearer home, they upset some of the most cherished theories held by pathologists. The assumption of displaced embryonic rests in the explanation of tumors will in many cases be found to be unnecessary. These mystical beings will, I trust, become less and less common as our knowledge of the development of the mesenchyme grows.

G. W. NICHOLSON,

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